



Photo: Innovative Design

Sustainable Schools create better learning environments

The objective of this Sustainable Schools Guide is to provide you with information that will allow your school system to make informed decisions regarding energy and environmental issues that are important to your school, community, and country.

The concept of sustainable development reflects an understanding that we must meet the needs of the present without compromising the ability of future generations to meet their own needs. A Sustainable School not only embraces the concept of sustainability but is, in itself, a teaching tool for sustainability.

"Good teachers never teach anything. What they do is create conditions under which learning takes place."

S.I. Hayakawa

By implementing the sustainable design practices included within these guidelines, you will be taking a significant step forward in creating the physical conditions in which the learning process can thrive.



Photo: Innovative Design

Reducing Operating Costs

Supporting Your Educational Mission

Today, depending upon your region of the country, between one-third and one-half of schools use excessive energy and up to one-third have unacceptable levels of indoor air pollution. In spite of shrinking operating budgets and rising energy costs, many schools continue to be designed with little or no consideration for the long-term impacts of energy and maintenance costs.

The difference between a well-designed, energy-efficient middle school and an average middle school often exceeds \$50,000 per year in energy costs.

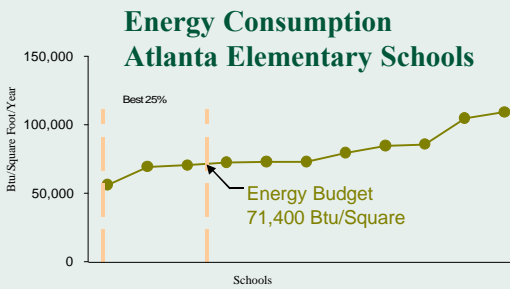


Photo: Innovative Design

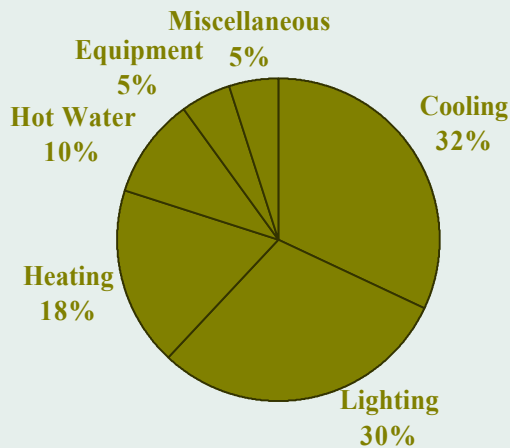
Over a ten year period, the difference could easily reach \$500,000 and, over the life of the facility, millions of dollars-- an unnecessary expenditure that could be better used in hiring additional teachers, purchasing computers, or providing other services and materials necessary for improving students' education.

There are many decisions that school boards and administrators make, but choosing to incorporate energy-efficient, environmentally-sound design practices is one that clearly supports you in meeting your district's educational goals. By implementing the recommended measures listed within these guidelines, your schools will not only save energy, but you will demonstrate to your students the importance of long-term thinking. These sustainable design measures will become teaching tools on how to save energy and protect our environment.

Insuring Success



Typical School Building Energy Loads



The New School, Apex, NC

✓ Establish an Energy Budget

Success starts with establishing goals. To insure that your school is energy efficient, you must first set a clear energy budget and then communicate that objective to your design team. Given your climatic region, building type, and minimum code requirement, this "energy budget" must be realistic, and it must be based upon the potential of current, proven energy-saving technologies.

The Atlanta, Georgia example depicts a simple procedure for establishing a realistic energy budget. The graph plots all schools that meet or surpass current energy codes (x-axis) and indicates energy consumption in terms of "Btus per square foot" (y-axis). The energy budget could be established by simply setting the goal at a level equal to that achieved by the top 25% in your district.

✓ Select a Qualified Design Team

Choose a team that has specific expertise in integrating energy and environmental considerations with the many other design issues and educational specifications that are typical in school design. When you are qualifying firms, ask them to provide you with examples of their successes in designing sustainable schools that have demonstrated good energy performance; information on daylighting and energy simulation tools that they use; and an explanation of how they integrate energy and environmental decision-making into their design process.

✓ Ask the Right Questions at the Right Time

To effectively integrate energy saving strategies into the overall design, options must be thoroughly analyzed from a "whole building perspective" early in the design process and, if deemed cost-effective, incorporated during the schematic design. Insist that your design team analyze all key energy-related systems in the schematic design phase.

✓ Balance Initial Costs Versus Life-Cycle Costs

Every school system faces the same problem in balancing initial costs versus life-cycle costs. To help solve this dilemma:

- have your school board establish basic policies that will allow for longer-term solutions;
- make sure that you are implementing the most cost-effective measures first; and
- investigate financing options available through Energy Service Companies that finance energy improvements based upon resulting energy savings.

✓ Involve Students, Teachers, and Maintenance Staff

The more your students, teachers, and maintenance staff are involved in and knowledgeable about, the sustainable features incorporated in your school, the more you will benefit. Regular informational updates to maintenance staff are critical.

Operating Costs

The following checklist outlines key sustainable elements that should be considered by your A&E team during the design of your school.

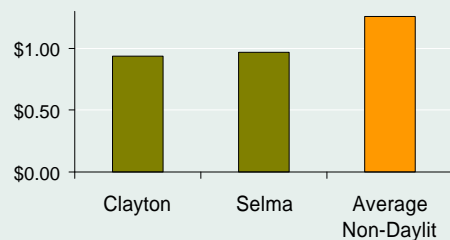


Durant Road Middle School, Raleigh, NC.

Johnston County Schools, NC

Johnston County built two daylit middle schools in 1993. Using an extensive south-facing roof monitor strategy, the 98,000 square foot Selma Middle School and 120,000 square foot Clayton Middle School were constructed using a prototype design that allowed for varying site orientations. In their first year of operation, the two middle schools used an average of 25% less energy than comparable schools in the same county and saved \$.32/square foot in energy bills. Since 1993, the two schools have saved Johnston County Schools in excess of \$500,000 in energy bills.

Yearly Average Energy Cost (\$ / SqFt)



Roof monitors at Clayton Middle School, Clayton, NC.

Site Design

- orient building to maximize solar access
- maximize daylighting possibilities with one story design
- consider seasonal variations in wind speed and direction
- design site to have easy, safe pedestrian access to surrounding communities and mass transit
- consider existing and new landscaping as a means of providing shading in the warmer months and a winter wind break

Daylighting & Windows

- create daylighting strategies that eliminate direct beam radiation from entering teaching and work spaces
- minimize east and west glass
- in colder regions, incorporate south-facing glass to maximize passive heating benefits and allow for better controlled daylighting
- in warmer regions use south- and north-facing glass to maximize daylighting and energy performance
- daylight the most utilized spaces, particularly classrooms
- use roof monitors with one-story buildings
- when considering daylighting, account for the benefits of:
 - smaller cooling equipment
 - reduced electrical service to site
 - less mechanical system maintenance
 - fewer lamp replacements
- in multi-story buildings, use lightshelves to bounce the light deeper into the spaces
- in lower windows not accounted for in daylighting strategies, use high-performance, low-e glass
- tint and/or shade east- and west-facing glass
- avoid the use of skylights that do not control summer overheating



Photo: Innovative Design

Four Oaks Elementary School, Four Oaks, NC

Ravenscroft School, NC

In an effort to improve comfort, reduce energy costs, and change the school's image, the Ravenscroft School, located in Raleigh, North Carolina, spent \$1.4 million to implement building shell improvements, integrate natural daylighting, and install a large solar pool heating and hot water system. The energy retrofits saved \$93,000 per year and reduced energy costs by over a dollar per square foot, to \$.43 per square foot.



Photo: Innovative Design

Before



Photo: Innovative Design

After



Photo: Jack Weirhold, Nantucket

Grid-connected photovoltaic system on Nantucket Elementary School

Energy-Efficient Building Shell

- use light colored exterior walls and white roofs to reduce cooling loads
- in warmer climates, use radiant barriers in the roof/ceiling assembly
- incorporate massive wall construction (e.g. brick or block) to slow heat flow into building
- optimally insulate walls and ceilings
- use light colored walls and ceiling inside to reduce lighting requirements
- caulk and seal all building shell penetrations to reduce infiltration impacts
- capitalize on masonry located inside the building shell's insulation to help stabilize temperature swings and reduce peak loads

Renewable Energy Systems

- because of energy, health, and productivity benefits associated with daylighting, consider this renewable option as your highest priority
- use solar electric and wind technologies in conjunction with battery storage to provide security lighting and emergency power supplies
- install photovoltaic systems as cost-effective means of providing power to remotely located crossway caution lights, sidewalk and parking lighting, sign lighting, and emergency call stations
- in mild to colder climates, consider passive heating strategies in connection with daylighting
- in summer peaking regions, evaluate solar absorption cooling systems and photovoltaics as strategies to reduce peak loads
- because of large hot water loads associated with cafeterias and shower areas, consider solar hot water systems
- in order to reduce cost and improve the appearance, integrate the solar thermal and photovoltaic systems into the building's wall and roof assemblies
- in high wind speed areas, consider wind turbines

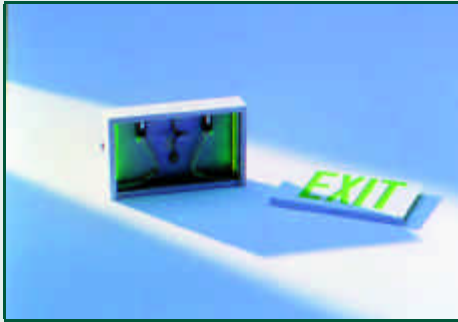


Photo: Astralite

LED exit sign 3000 ALS

Daniel Boone High School, TN

The 160,000 square foot Daniel Boone High School, built in 1971, was heated by electricity and cooled by a two-pipe chilled water system. After analysis of other two-pipe retrofit options, a new geothermal heat pump system was installed in 1995-96. Costing an additional \$197,000, and saving \$33,000 versus the next best two-pipe system considered, the geothermal system saved Washington County Schools, Tennessee, \$62,000 the first complete year of operation.

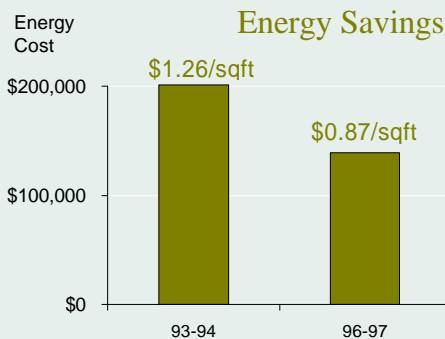


Photo: Innovative Design

Ice storage system. East Clayton Elementary School. Clayton, NC

Lighting and Electrical Systems

- select lamps with high lumens per Watt
- use long-life lamps to reduce maintenance
- select lighting systems compatible with daylighting
- in spaces that receive daylight, incorporate controls that are tied to photocells and either dim (best option) or, through multi-level switching, automatically reduce or increase light levels
- incorporate occupancy sensors to automatically turn off lights in non-occupied spaces
- provide photocell controls on exterior lights to insure lights are not operating during the day
- use energy-efficient lamps and electronic ballasts, particularly in non-daylit spaces
- use light-emitting diode (LED) type exit lights
- consider indirect lighting strategies as a means to minimize glare
- minimize electrical line losses by installing a high voltage distribution system

Mechanical & Ventilation Systems

- consider initial cost of equipment, anticipated maintenance expenses, and projected operating costs, in evaluating system options
- insist on designers using a computer energy analysis program that simulates hourly, daily, monthly, and yearly energy consumption and effectively accounts for daylighting benefits (i.e., reduced cooling)
- eliminate systems that first cool air, then reheat it, or mix cool and hot air
- do not oversize cooling equipment
- implement a strategy that will insure adequate fresh air
- incorporate economizer cycles and heat recovery systems
- employ thermal storage in regions with high peak load pricing
- locate the ductwork within conditioned or semi-conditioned spaces
- if a particular mechanical system serves more than one space, insure that each space served has the same orientation and fulfills similar functions
- when climatic conditions allow, install operable windows to improve indoor air quality

Environmentally-Sensitive Building Products and Systems



Photo: Barry Halking Photography, PA

Recycled tiles in cafeteria. University City High, Philadelphia, PA



Photo: Innovative Design

Rainwater tank at Roy Lee Walker Elementary School, McKinney, TX

- incorporate less polluting materials, the result being a reduced requirement for mechanically induced fresh air and better energy efficiency
- incorporate pollutant sensors to allow you to take advantage of reducing air exchange during non-occupied times
- incorporate materials with low maintenance requirements

Water Conservation

- incorporate indigenous vegetation to minimize irrigation requirements
- use rainwater for toilet flushing and irrigation, thus reducing long-term water costs as well as reducing the need for site retention ponds
- encourage general contractor to conserve water during the construction
- investigate graywater options for irrigation
- use water conserving fixtures

Recycling Systems and Waste Management

“In the United States, building accounts for 20% of the 221.7 million tons of daily trash; that’s 44.34 million tons of trash coming from our building sites each day.”

Worldwatch Institute, 1995

- implement a long-term strategy to reduce waste going to landfills
- place receptacles and centralized bins to facilitate use and collection
- involve students in comprehensive recycling effort
- require contractors to recycle appropriate construction waste materials

Transportation

- work with developers and local planning departments to design easy, safe pedestrian access
- develop a pedestrian-friendly school site which accesses community sidewalks and bike paths, reducing busing and single car drop-offs
- use high-efficiency and low-emission natural gas, biodiesel, methanol, and solar electric buses and service vehicles
- install strategically-placed bike racks that encourage student use
- provide easy, safe access to public transportation

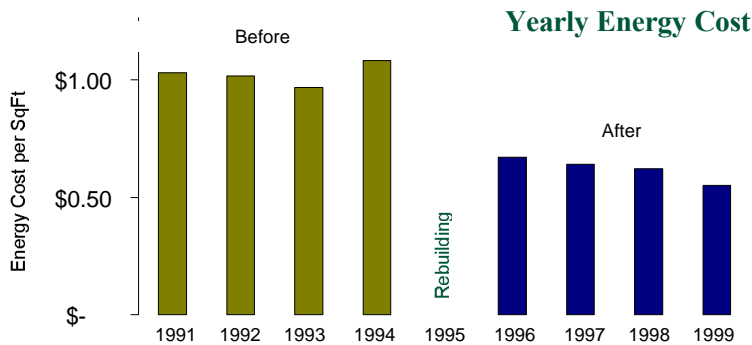


Photo: Innovative Design

Safe walkways connecting the school to surrounding neighborhoods.

Oquirrh Hills Elementary School

West Jordan, Utah



In 1995, Oquirrh Hills Elementary School was destroyed by fire. But this accident provided Jordon School District new opportunities, and out of these ashes was built a new state-of-the-art, energy-efficient school. Built on the original foundation, the new 61,200 square-foot school has a light colored roof to reduce the cooling loads and R-30 rigid insulation. Exterior windows have low-E glass. The interior finishes are light colored to reduce the lighting requirements. Comfort and energy savings were further enhanced with T-8 fluorescent lamps with electronic ballasts, energy management control. Through the incorporation of these simple, cost-effective solutions, the new school spends about \$22,000 less per year in operating costs compared to the old school.

Interdistrict Downtown School

Minneapolis, Minnesota



Case Studies

Owner:

Jordon School District
9150 South 500 West
Sandy, Utah 84070

Contact:

Duane Devey
Phone: 801-567-8770.

Architect:

Valentiner, Crane, Brunjes & Onyon
Architects
Salt Lake City, Utah

Owner:

Interdistrict Downtown School
10 South 10th Street
Minneapolis, MN 55403

Contact:

Barbara Shin, Principal
Phone: 612-752-7100

Architect:

Cunningham Group
Minneapolis, MN

The Interdistrict Downtown School in Minneapolis, Minnesota is a multi-cultural magnet school for 520 students, kindergarten through twelfth grade. The school was completed in 1998, and incorporates a 2,115 square foot solar wall heating system. The \$50,000 active solar collector brings in outside air through perforations in the collector, and is heated by the sun. The warm air is sent into the building's HVAC system. The collector, which was installed on the south penthouse wall, not only saves \$5,600 per year in energy, but more importantly, serves as an educational tool, introducing students to renewable energy principles. On a typical winter day, the solar collector is capable of preheating the air entering a building by 30°F.

Case Studies

Durant Road Middle School

Raleigh, North Carolina

"Everything...here really provides the opportunity to these young students to learn more and to save energy. It's going to be another tool for your education."

Hazel O'Leary, Former Secretary, US Department of Energy



Photo: Robert Flynn

"In order to accommodate our school system's phenomenal growth, we are proud that our Board of Education and facilities administrators have seen fit, not just to construct buildings which meet our immediate needs, but have invested in facilities which should provide efficient and cost-effective operating margins for the future as well. Schools like Durant Road Middle give us an edge against rising energy prices, and should prove especially beneficial as we face the uncertainty of deregulation and its affects on utility rates."

Mazie Swindell Smith, Organizational Development Administrator
Wake County Public School System

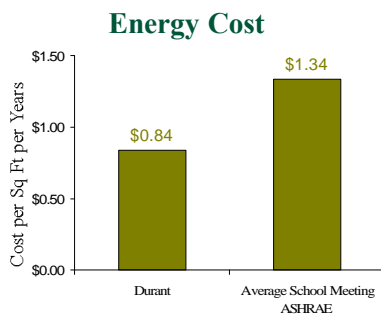


Photo: Innovative Design

Owner:

Wake County Schools
1551 Rock Quarry Road
Raleigh, NC 27610

Contact:

Tom Benton, Principal
Phone: 919-870-4098

Architect:

Innovative Design, Raleigh, NC

Durant Road Middle School is a fully daylit school operating on a year-round schedule. It began operation at the beginning of the 1995-96 school year. Despite the extensive daylighting strategy, the \$12.3 million school was actually bid \$3.6 million less than budgeted by the school board. The daylighting components added to the initial cost of the building. However, because of cooling and lighting load reductions made possible by the daylighting and building shell efficiency measures, the net initial cost was only \$115,000, or less than 1% of the total construction budget. The daylighting and energy efficiency measures are saving \$77,000 per year over the average "10 month" schools meeting equivalent fresh air standards, and the investment has been returned to the school system in less than two years.

Daylighting Boosts Productivity and Health of Students and Staff

The daylighting design at Durant Road Middle school is also helping the students and staff in other ways. The school has maintained very high attendance rates since it opened, consistently staying near 98% daily attendance, compared to about 95% county wide. In 1996, Durant Road had the highest attendance rate in Wake County's one hundred school system.

Case Studies

Spirit Lake Community Schools

Spirit Lake, Iowa

"The final payment for the loan on the first turbine was made during the 1998 fiscal year. Today, \$25,000 per year in savings go to the school's instructional programs."

Jim Tirevold, Facilities Manager, Spirit Lake Community Schools

On July 22, 1993, the wind turbine on the lawn of the Spirit Lake Elementary school began producing electricity. By August 2000, seven years and two months later, the school's turbine had produced a total output of 2,068,803 kiloWatt hours of electricity, which saved the district \$176,445 in reduced electricity costs. This corresponds to an average electrical output of 288,670 kiloWatt hours per year and an average savings of \$24,620 per year. Looking at the entire seven year, two month period of operation, nearly all of the electrical needs of the elementary school have been met by the wind turbine.

In addition to its excellent financial success, the school's wind turbine has been used in the curriculum as an educational tool and has made a significant contribution to the environment. The 2,068,803 kWh of electricity produced by the turbine in the first 86 months of operation is the energy equivalent of 3,641 barrels of oil or 1,034 tons of coal. It has eliminated 3,103,205 pounds of CO₂ emissions and 442,724 pounds of SO₂ emissions that would have been released to the atmosphere by conventional energy production.



Photo: American Wind Energy Association



Photo: Solar Now

Beverly High School

Beverly, Massachusetts

Owner:

Beverly High School
100 Sohier Road
Beverly, MA 01915

Contact:

Carmel Valianti-Smith, Project Director
Solar Now Center for Renewable Energy Education
Phone: 508-927-9SUN

In 1980, Beverly High School, installed a 100-kiloWatt photovoltaic system that continues to save the school between \$10,000 and \$20,000 annually. In 1994, Ms. Valianti-Smith and her students launched an enhanced renewable energy educational program that resulted in the addition of a 10-kiloWatt wind turbine. Today, Carmel Valianti-Smith is director of the international organization, Solar Now, a non-profit organization dedicated to teaching students about the benefits of solar energy.

Financing

Your Energy Improvements

Energy performance contracting is an increasingly popular means by which local school systems strapped for capital funds can afford energy improvements that not only address rising energy costs but also help create better learning environments. The following examples represent a few of the hundreds of successful initiatives occurring across the country.

Rabun County Schools Saving \$ 45,000 Annually

Faced with no capital funds but a real need to improve the lighting and mechanical systems in their five schools, Rabun County Schools, Georgia, turned to the Southern Company's energy service company - Energy Solutions. The school system entered into a \$350,000 performance contract that required no money upfront and is now being paid for with energy savings. In addition to the \$45,000 annual savings, the better light quality and improved thermal comfort has significantly improved the learning environment.

Contact:

Charles Prince
Rabun County Schools
PO Box 468, Clayton, GA 30525
Phone: 706-746-5376

The Montour School District in southwest Pennsylvania, seeking to improve their schools' learning environments and reduce operating costs, signed an energy performance contract with

OnDemand Energy Solutions. Implementing a comprehensive energy retrofit package that included lighting, HVAC, control upgrades and maintenance, the energy service company is guaranteeing that they will save the district \$1 million over the 10 year contract period. No upfront investment was required by the school system. All the improvements are being financed by energy savings, and at the end of the ten year contract all the equipment and future savings are retained by Montour School District.

No Up-front Costs - \$100,000 Per Year Savings for Montour Schools

Contact:

Andy Pavucek
Montour School District
Clever Road, McKees Rock, PA 15136
Phone: 412-490-6500

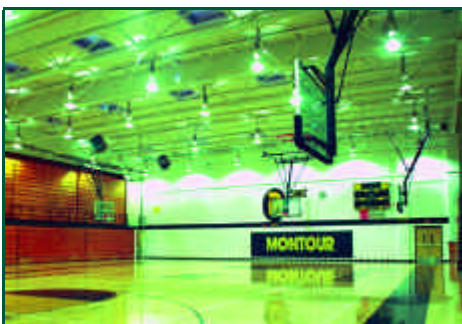


Photo: Montour School District

Maintenance Matters

Contact:

Stu Reeve, Energy and Technical Systems
Poudre School District
2413 LaPorte Avenue
Fort Collins, CO 80521
Phone: 970-490-3502



Photo courtesy: Poudre School District

Green Team Produces Results

The "green team" approach to maintenance is paying off for the Poudre School District, saving over three-quarters of a million dollars since 1994. Their success is attributed to not only involving the district's energy manager and conservation team, but also engaging each individual school manager, head custodian, site energy efficiency coordinator, student, and teacher. The team approach has resulted in substantial energy savings and a better appreciation of energy conservation's value and how it impacts the sustainability of our planet.



Photo courtesy: Mount Baker School District

Washington State School District Saves \$25,000 Annually in Recycling Effort

The Mount Baker School District's recycling effort is in its eighth year and is now saving \$25,000 annually. Successful because of its outstanding student participation, the award winning program has a long list of materials that they recycle or reuse. The program is totally self-supporting, and last year the students saved \$18,000 through recycling and reuse and an additional \$7,000 from avoided disposal fees.

Contact:

Becky Phillips
Mount Baker School District
PO Box 98244, Deming, WA 98244
Phone: 360-383-2000

Trying to maximize their financial resources, Wake County Schools has made saving energy a high priority within the 90,000 student, 100 campus system. Their efforts have been rewarded by saving in excess of \$600,000 per year in energy bills. Much of this success is directly attributed to an emphasis on training and involvement of employees and students. The school system encourages individual schools to save energy by offering each school 10% of the annual savings, and rewards maintenance staff at high-performing schools with special recognition and gift certificates.



Photo: Innovative Design

Rebates are Key to Energy Savings

Contact:

Mazie Swindell Smith or Kris Bowen
Wake County Schools
1551 Rock Quarry Road
Raleigh, NC 27610
Phone: 919-856-8048

For Helpful Resources and More Information

Initiatives

Alliance to Save Energy

www.ase.org/greenschools

American Electric Power's Solar Schools Project

www.aep.com/environment/solar

Energy Quest

www.energy.ca.gov/education

Energy Smart Schools

www.eren.doe.gov/energysmartschools

Maryland's Solar Schools Program Plan

www.energy.state.md.us/executiv.htm#Plan

On-Line Renewable Energy Education Module

solstice.crest.org/renewables/re-kiosk/index.shtml

Solar Energy: A Science Unit for Intermediate Grade Students

alpha.fsec.ucf.edu/ed/solar-unit

School Going Solar Program- IREC

www.schoolsgoingsolar.org

Solar Schools - Brighter Future

www.ises.org

Solar Now

www.eren.doe.gov/solarnow/solarnow.htm

SolarQuest

www.solarquest.com

Solar Schools

www.eren.doe.gov/solarschools

Training Student Organizers Program

www.cenyc.org/HTML/EE/mainee.htm

Watts on Schools

www.wattsonschoools.com

Organizations

American Solar Energy Society

www.ases.org/solarguide

Center for Renewable Energy and Sustainable Technology (CREST)

solstice.crest.org

Energy Center

www.caddet-re.org

Energy Efficiency and Renewable Energy Network (DOE)

www.eren.doe.gov

Florida Solar Energy Center

www.fsec.ucf.edu

International Solar Energy Society

www.ises.org

Interstate Renewable Energy Council

www.irecusa.org

Million Solar Roofs Initiative

www.millionsolarroofs.org

National Energy Education Development (NEED)

www.need.org/need

National Network of Energy and Environmental Education Professionals

www.leeric.lsu.edu/network/network.htm

National Renewable Energy Laboratory

www.nrel.gov/ceb.html

North Carolina Solar Center

www.ncsc.ncsu.edu

Solar Energy Industries Association

www.seia.org

Solar Energy Research and Education Foundation

www.seref.org

US Department of Energy

www.doe.gov

This document has been developed by Innovative Design with technical assistance from Padia Consulting, BuildingGreen, and the Sustainable Buildings Industry Council and has been extensively reviewed by a technical review committee with broad based expertise in education, as well as energy and environmental issues.

Although great care has been taken in preparation of this guide, no warranties, expressed or implied, are given in connection with any of the information enclosed, and no responsibility can be taken by Innovative design or any of its consultants for any claims arising herewith. Comments, criticisms, clarifications, and suggestions regarding subject matter are invited.

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This document was specifically developed for school board members and school system administrators and it is part one in a six part series on how implementing energy-efficient, environmentally-sound construction practices can help you in addressing your educational mission.

The Sustainable Schools Guide includes:

- **Reducing Operating Costs**
- **Buildings that Teach Sustainability**
- **Improving Academic Performance**
- **Protecting our Environment**
- **Improving Health, Safety & Comfort**
- **Supporting Community Values**