

# PUBLIC INPUT SIGN UP SHEET

5-7-07

**PUBLIC INPUT SHALL BE LIMITED TO  
THREE (3) MINUTES PER PERSON.**

**EACH PERSON SHOULD:**

- (1) STATE YOUR NAME
- (2) IN WHAT AREA OF THE COUNTY YOU LIVE
- (3) SPEAK IN A CLEAR AND COURTEOUS MANNER.

*Please Print:*

	<u>NAME</u>	<u>ADDRESS</u>	<u>ISSUE</u>
hand-out	1. BARBARA A. BARNETT	602 Water Oak Ln, H'ville	"Green Schools"
hand-out	2. Eva Ritchey	1928 Brevard Rd, H'ville	Land Use + Energy
	3. Carole Repici	609 Carriage Commons Dr - H'ville	
hand-out	4. Tim Wohlgenuth	44 Springside Ct, H'ville	
hand-out	5. Dr. Stan Pienst	622 Rugby View Place, H'ville NC 28791	
	6. Robert Armstrong	160 Mt. Valley Dr.	Strategic Plan / Schools
	7. Sharon Maylin		
	8. Susan U. Stewart	80 Bay Willow Ct	Green schools
	9. Randy Neall	3033 TIBBON TAILS	HEWLETT PACKARD INC
	10.		
	11.		
	12.		
	13.		

## Resolution

Supporting S1427 and H1077 to purchase capital equipment, make facility upgrades, and offset administrative start-up costs for its Custom Medical Products Initiative (MCMP).

**WHEREAS**, The Marketing Association of Rehabilitation Centers (MARC) , celebrates thirty continuous years of providing sustainable jobs at thirteen locations, serving twenty-one western rural counties from Wilkes and Ashe in the northwest to Cherokee in the far west portion of North Carolina ,with the mission of supporting vocational rehabilitation and developmental training for adults with physical and mental disabilities or both.

**WHEREAS**, These member community facilities have a total workforce of 2,474 and of this workforce, 1,669 or 67% are workers with a disability. Nationally, almost 70% of individuals with disabilities remain unemployed, but within the region served by MARC, that figure drops to 45%.

**WHEREAS**, MARC facilities produce an annual payroll of over \$14,270,000 plus benefits that, in turn, are reinvested back into their communities. As a result, adults with severe disabilities are afforded a positive work and training environment each and every day to maintain their level of independence and self-worth as productive citizens.

**WHEREAS**, MARC is launching an economic development initiative, MARC Custom Medical Products (MCMP). MCMP joins nine Community Rehabilitation Programs to manufacture custom disposable surgical drapes and other devices used in medical procedures. MCMP will create or retain 250 jobs, two-thirds of which will be for people with disabilities, and generate \$5.1 MM in incremental sales within a three year developmental period.

**WHEREAS**, Funding partners for MCMP include: AdvantageWest, The Golden LEAF Foundation, North Carolina Department of Commerce, North Carolina Rural Center, The Janirve Foundation, along with current MARC membership. These and future funding partners will allow facilities to continue current program offerings to offset reoccurring state funding shortfalls totaling \$ 1.4 million dollars.

**WHEREAS**, This region-wide job creation and retention initiative will provide pillars of manufacturing in member counties; adding jobs, through community based, small business driven social enterprises, such as Vocational Solutions of Henderson County.

**NOW, THEREFORE LET IT BE RESOLVED**, that the Henderson County Board of Commissioners supports the efforts of our regional and local community rehabilitation center, Vocational Solutions, and is in support and passage of Senate Bill 1427, and House Bill 1077 for an appropriation of \$ 1,000,000.00 to purchase capital equipment, make facility upgrades, and offset administrative start-up costs for its Custom Medical Products Initiative.

Adapted this the 4<sup>th</sup> day of June, 2007

ATTEST:



  
Chairman  
  
Clerk to the Board

LINE-ITEM TRANSFER REQUEST  
HENDERSON COUNTY



Department: PUBLIC SCHOOL CAPITAL PROJECTS

Please make the following line-item transfers:

What expense line-item is to be increased?

Account	Line-Item Description	Amount
<u>115980-598043</u>	<u>TRANSFER TO SCHL CAP PROJ</u>	<u>\$ 525,000</u>
<u>435691-551000-0505</u>	<u>CAPITAL OUTLAY-EQUIPMENT</u>	<u>\$ 525,000</u>
_____	_____	_____
_____	_____	_____

What expense line-item is to be decreased? Or what additional revenue is now expected?

Account	Line-Item Description	Amount
<u>115691-569907</u>	<u>CAPITAL EXPENSE-SCHOOLS</u>	<u>\$ 525,000</u>
<u>434691-403500-0505</u>	<u>TRANSFER FROM GENERAL FUND</u>	<u>\$ 525,000</u>
_____	_____	_____

**Justification:** *Please provide a brief justification for this line-item transfer request.*

BUDGET AMENDMENT TO TRANSFER ONE-TIME FUNDING APPROPRIATED IN THE CURRENT FISCAL YEAR BUDGET FOR NEW SUGARLOAF ROAD ELEMENTARY FURNITURE & EQUIPMENT TO THE SCHOOLS CAPITAL PROJECT FUND (FUND 43) FOR PURCHASE DURING FY2008 WHEN SCHOOL PROJECT IS COMPLETED.

FINANCE \_\_\_\_\_ 5/7/2007  
Authorized by Department Head \_\_\_\_\_ Date

\_\_\_\_\_  
Authorized by Budget Office \_\_\_\_\_ Date

\_\_\_\_\_  
Authorized by County Manager \_\_\_\_\_ Date

*approved  
5-7-07*

*For Budget Use Only*

Batch # \_\_\_\_\_

Batch Date \_\_\_\_\_

HENDERSON COUNTY COMMISSION MEETING  
May 7, 2007

100 King Street, Hendersonville, NC

**STATEMENT TO THE BOARD**

**Good Evening, I'm Barbara A. Barnett, Spokesperson for the Four Seasons Sierra Committee of Henderson County. Global Warming and Climate Change are household words. 90 % of the public are concerned, don't know how to fix it and look to government for leadership according to a Stanford University Study.**

**The North Carolina State Energy Plan proposes a solar school program incorporating renewable electricity generation, solar water heating and daylighting to reduce fossil fuel use by schools, improve the quality of education, provide a real-world energy training lab and make our citizens more aware of the potential for renewable resources.**

**The Henderson County Commission has taken a first step in approving two new elementary schools (Mill River & Hillandale) and hopefully will choose a 21<sup>st</sup> Century State of the Art Environmentally Sound Design.**

**Senate Bill S927 creates the Green School Construction Revolving Loan Fund for NO-INTEREST LOANS to local school Boards of Education and to establish the Green School Construction Program for construction or major renovation of high-performance school buildings**

**The Four Seasons Sierra Committee urges your consideration and active participation and support for this bill because it addresses the major financial roadblock to building "GREEN SCHOOLS". Thank you.**



**Barbara A. Barnett  
Four Seasons Sierra Committee  
602 Water Oak Lane, Hendersonville, NC 28791**

**828-694-3738    maubar53@bellsouth.net**

*cc: BOC  
Steve*

*P.S. Copy of S 927 Green Schools Bill attached.*

GENERAL ASSEMBLY OF NORTH CAROLINA  
SESSION 2007

S

1

SENATE BILL 927

Short Title: Green School Construction Loan Fund/Program.

(Public)

Sponsors: Senator Garrou.

Referred to: Finance.

March 20, 2007

A BILL TO BE ENTITLED

AN ACT TO CREATE THE GREEN SCHOOL CONSTRUCTION REVOLVING  
LOAN FUND TO BE USED FOR NO-INTEREST LOANS TO LOCAL BOARDS  
OF EDUCATION FOR CERTAIN ENERGY-RELATED CONSTRUCTION,  
COMMISSIONING, AND INSTALLATION PROJECTS AND TO ESTABLISH  
THE GREEN SCHOOL CONSTRUCTION PROGRAM, A VOLUNTARY  
PROGRAM FOR THE CONSTRUCTION OR MAJOR RENOVATION OF  
HIGH-PERFORMANCE SCHOOL BUILDINGS.

The General Assembly of North Carolina enacts:

**SECTION 1.** Article 37 of Chapter 115C is amended by adding two new sections to read:

**§ 115C-521.1. Green School Construction Loan Fund.**

(a) The Green School Construction Loan Fund is created under the control and direction of the Department of Public Instruction. This Loan Fund shall be a nonreverting revolving loan fund consisting of any moneys appropriated to it by the General Assembly, other moneys paid to it as gifts or grants, or any moneys repaid or recovered on behalf of the Loan Fund. The Loan Fund shall be credited with interest on the Loan Fund by the State Treasurer pursuant to G.S. 147-69.2 and G.S. 147-69.3.

(b) The Loan Fund shall be used to provide no-interest loans to local boards of education for any of the following purposes, with priority given to projects that will have the greatest impact on reducing the use of energy and water:

(1) For all or part of the incremental cost of designing, constructing, and certifying a new school facility or a major renovation of an existing school to at least the LEED silver standard under G.S. 115C-521.2, to be calculated by comparing the total cost of the project to the cost of substantially the same project using conventional design and construction.

(2) For all or part of the incremental cost of designing and constructing a new school facility or a major renovation of an existing school in

1 accordance with the North Carolina sustainable school design protocol  
2 standards under G.S. 115C-521.2, to be calculated by comparing the  
3 total cost of the project to the cost of substantially the same project  
4 using conventional design and construction.

5 (3) For all or part of the cost of commissioning a school building for the  
6 purpose of reducing the building's use of energy or water, including  
7 installing an alternative energy system, when the commissioning under  
8 this subdivision is not suitable for a guaranteed energy savings  
9 contract under Part 2 of Article 3B of Chapter 143 of the General  
10 Statutes.

11 (4) For all or part of the cost of installing in a school building one or more  
12 energy conservation measures, as defined in G.S. 143-64.17, when  
13 these energy conservation measures are not suitable for a guaranteed  
14 energy savings contract under Part 2 of Article 3B of Chapter 143 of  
15 the General Statutes.

16 (5) For all or part of the cost of installing in a school building an  
17 alternative energy system to replace a conventional energy system  
18 when the installation of the alternative energy system is not suitable  
19 for a guaranteed energy savings contract under Part 2 of Article 3B of  
20 Chapter 143 of the General Statutes.

21 (b) After consulting with the State Energy Office of the Department of  
22 Administration, the Department of Public Instruction shall adopt rules to administer the  
23 Loan Fund and to establish prioritization for loans, maximum loans, application, and  
24 award criteria and schedules, and to otherwise implement this section.

25 **"§ 115C-521.2. Green School Construction Program to construct**  
26 **high-performance school buildings.**

27 (a) The General Assembly finds that high-performance school buildings are  
28 proven to increase student test scores, reduce absenteeism, and cut energy and other  
29 utility costs. It is the intent of the General Assembly to encourage local boards of  
30 education to use recognized standards for the construction of high-performance public  
31 school buildings that provide flexible methods and choices in how to achieve those  
32 standards. It is the intent and an established goal of the Leadership in Energy and  
33 Environmental Design (LEED) program as authored by the United States Green  
34 Building Council to increase demand for building materials and products that are  
35 extracted and manufactured locally, thereby reducing the environmental impacts and to  
36 support the local economy. Accordingly, it is the intent of the General Assembly to  
37 encourage local boards of education to participate in achieving this goal and voluntarily  
38 establish a priority to use North Carolina-based resources, building materials, products,  
39 industries, manufacturers, and other businesses to provide economic development to  
40 North Carolina and to meet the objectives of this section.

41 (b) The Green School Construction Program under this section shall be  
42 administered by the Department of Administration. Any major school facility project  
43 may, as determined by the local board of education, be designed and constructed to at  
44 least the LEED silver standard or in accordance with the North Carolina sustainable

1 school design protocol standards to the extent appropriate LEED silver or North  
2 Carolina sustainable school design protocol standards exist for the type of building or  
3 facility.

4 (c) Any local board of education that uses the high-performance standard under  
5 this section is encouraged to:

6 (1) Monitor and document appropriate operating benefits and savings  
7 resulting from major facility projects designed and constructed under  
8 this section for a minimum of five years following local board  
9 acceptance of the project; and

10 (2) Report annually to the Department of Administration and to the  
11 Superintendent of Public Instruction on a form developed by the  
12 Department of Administration.

13 (d) Any major school facility project designed to meet standards identified for  
14 high-performance school buildings in this section shall include building commissioning  
15 as a critical cost-saving part of the construction process. This process shall include input  
16 from the project design and construction teams, representatives of the local board of  
17 education, and the State Energy Office of the Department of Administration.

18 (e) In order to be able to monitor and document ongoing operating benefits and  
19 savings under subsection (c) of this section, a local board of education is encouraged to  
20 require all utilities going into any school building that is the subject of a major facility  
21 project under this section to be metered.

22 (f) A member of the design or construction teams shall not be held liable for the  
23 failure of a major facility project to meet the high-performance building standard under  
24 this section that is established for the project as long as a good faith attempt was made  
25 to achieve this standard.

26 (g) No later than September 1 of each year, the Department of Administration  
27 shall consolidate the reports required in subsection (c) of this section into one report and  
28 submit this report, along with input from the Department of Public Instruction, to the  
29 Chairs of the Senate and House Appropriations Committees and the Joint Legislative  
30 Commission on Governmental Operations. The Department of Public Instruction and  
31 the Department of Administration may make recommendations regarding the ongoing  
32 implementation of the Green School Construction Program, may include a discussion of  
33 current incentives and disincentives related to implementing this section, and may  
34 comment on the performance of the Program, including any changes that may be needed  
35 to adapt the Program to any new or modified standards for high-performance buildings  
36 that are consistent with the intent of this section.

37 (h) The Department of Administration, in consultation with the Superintendent of  
38 Public Instruction, shall develop and issue guidelines to implement this section. The  
39 guidelines shall define a procedure and method for employing and verifying activities  
40 necessary for certification to at least the LEED silver standard for major school facility  
41 projects. The Department of Administration and the Department of Public Instruction  
42 shall amend their fee schedules for architectural and engineering services to  
43 accommodate the requirements in the design of major school facility projects that are  
44 subject to this section.

1       (i) The Department of Administration and the State Board of Education may  
2 adopt rules needed to implement this section.

3       (j) As used in this Article, the following definitions apply:

4           (1) "High-performance school building" means a school building  
5 designed, constructed, and certified to a standard as identified in this  
6 section.

7           (2) "LEED silver standard" means the U.S. Green Building Council  
8 Leadership in Energy and Environmental Design (LEED) green  
9 building rating standard referred to as the LEED Silver Standard, as  
10 amended.

11           (3) "Major facility project" means a construction project larger than 5,000  
12 gross square feet of occupied or conditioned space as defined in the  
13 North Carolina State Building Code or a building renovation project  
14 when the cost is greater than fifty percent (50%) of the assessed value  
15 and the project is larger than 5,000 gross square feet of occupied or  
16 conditioned space as defined in the North Carolina State Building  
17 Code. "Major facility project" does not include any of the following:  
18 research facilities primarily used for sponsored laboratory  
19 experimentation, laboratory research, or laboratory training in research  
20 methods, or other similar building types as determined by the  
21 Department of Administration.

22           (4) "North Carolina sustainable school design protocol standards" means  
23 the school design protocol and related information developed by the  
24 Department of Public Instruction under G.S. 115C-521."

25       **SECTION 2.** Article 31 of Chapter 115C of the General Statutes is amended  
26 by adding a new section to read:

27 **"§ 115C-426.3. Monitor and report utility consumption by local administrative**  
28 **units.**

29       (a) Each local school administrative unit that participates in the Green School  
30 Construction Program under G.S. 115C-521.2 shall monitor and report utility  
31 consumption for purposes of reporting to the Superintendent of Public Instruction as  
32 provided in G.S. 143-135.38."

33       **SECTION 3.** In recognition that the North Carolina Energy Guidelines for  
34 School Design and Construction that were developed and maintained by the Department  
35 of Public Construction under G.S. 115C-521 are no longer sufficient in regard to a  
36 comprehensive approach to energy efficiency in school design, school construction, and  
37 school operation and maintenance, the State Energy Office within the Department of  
38 Administration shall develop and maintain the North Carolina sustainable school design  
39 protocol standards to be used for the construction of all new school buildings and the  
40 repairing of all old school buildings under the control and direction of, and by contract  
41 with, the board of education. The North Carolina sustainable school design protocol  
42 standards shall be used in lieu of the North Carolina Energy Guidelines for School  
43 Design and Construction. The North Carolina sustainable school design protocol  
44 standards shall be at least as stringent as the sustainable school design protocol



1 standards developed in the State of Washington, as mandated by their legislature. The  
2 North Carolina sustainable school design protocol standards shall include a voluntary  
3 pass/fail rating system to evaluate a school's progress toward sustainability. This rating  
4 system shall be comprised of a number of prerequisites and optional sustainability  
5 measures developed by the State Energy Office. Each board of education participating  
6 in this protocol may choose from among the list of optional measures to chart a path  
7 toward sustainability specific to the site of the school and the goals of the board of  
8 education.

9 **SECTION 4. G.S. 115C-521 reads as rewritten:**

10 **"§ 115C-521. Erection of school buildings.**

11 (a) It shall be the duty of local boards of education to provide classroom facilities  
12 adequate to meet the requirements of G.S. 115C-47(10) and 115C-301. Local boards of  
13 education shall submit their long-range plans for meeting school facility needs to the  
14 State Board of Education by January 1, 1988, and every five years thereafter. In  
15 developing these plans, local boards of education shall consider the costs and feasibility  
16 of renovating old school buildings instead of replacing ~~them~~ and, employing  
17 life-cycle cost analysis as defined in G.S. 143-64.11, shall consider the feasibility and  
18 costs of commissioning the old school buildings that are renovated for the purpose of  
19 reducing energy and water use.

20 (b) It shall be the duty of the boards of education of the several local school  
21 administrative school units of the State to make provisions for the public school term by  
22 providing adequate school buildings equipped with suitable school furniture and  
23 apparatus. The needs and the cost of those buildings, equipment, and apparatus, shall be  
24 presented each year when the school budget is submitted to the respective tax-levying  
25 authorities. The boards of commissioners shall be given a reasonable time to provide the  
26 funds which they, upon investigation, shall find to be necessary for providing their  
27 respective units with buildings suitably equipped, and it shall be the duty of the several  
28 boards of county commissioners to provide funds for the same.

29 Upon determination by a local board of education that the existing permanent school  
30 building does not have sufficient classrooms to house the pupil enrollment anticipated  
31 for the school, the local board of education may acquire and use as temporary  
32 classrooms for the operation of the school, relocatable or mobile classroom units,  
33 whether built on the lot or not, which units and method of use shall meet the approval of  
34 the School Planning Division of the State Board of Education, and which units shall  
35 comply with all applicable requirements of the North Carolina State Building Code and  
36 of the local building and electrical codes applicable to the area in which the school is  
37 located. These units shall also be anchored in a manner required to assure their  
38 structural safety in severe weather. The acquisition and installation of these units shall  
39 be subject in all respects to the provisions of Chapter 143 of the General  
40 Statutes-Statutes, including the provisions of Part 1 of Article 3B of that Chapter,  
41 Energy Policy and Life-Cycle Cost Analysis. The provisions of Chapter 87, Article 1, of  
42 the General Statutes, shall not apply to persons, firms or corporations engaged in the  
43 sale or furnishing to local boards of education and the delivery and installation upon

1 school sites of classroom trailers as a single building unit or of relocatable or mobile  
2 classrooms delivered in less than four units or sections.

3 (c) The building of all new school buildings and the repairing of all old school  
4 buildings shall be under the control and direction of, and by contract with, the board of  
5 education for which the building and repairing is done. If a board of education is  
6 considering building a new school building to replace an existing school building, the  
7 board shall not invest any construction money in the new building unless it submits to  
8 the State Superintendent and the State Superintendent submits to the North Carolina  
9 Historical Commission an analysis that compares the costs and feasibility of building  
10 the new building and of renovating the existing building and that clearly indicates the  
11 desirability of building the new building. No board of education shall invest any money  
12 in any new building until it has (i) developed plans based upon a consideration of the  
13 State Board's ~~facilities guidelines, guidelines and consideration of ways to minimize the~~  
14 new building's use of energy and water, (ii) submitted these plans to the State Board for  
15 its review and comments, and (iii) reviewed the plans based upon a consideration of the  
16 comments it receives from the State Board. No local board of education shall contract  
17 for more money than is made available for the erection of a new ~~building~~  
18 however, any money obtained as no-interest loans under G.S. 115C-521.1 shall be  
19 included as available money. However, this subsection shall not be construed so as to  
20 prevent boards of education from investing any money in buildings that are being  
21 constructed pursuant to a continuing contract of construction as provided for in  
22 G.S. 115C-441(c). All contracts for buildings shall be in writing and all buildings shall  
23 be inspected, received, and approved by the local superintendent and the architect  
24 before full payment is made therefor. Nothing in this subsection shall prohibit boards of  
25 education from repairing and altering buildings with the help of janitors and other  
26 regular employees of the board.

27 In the design and construction of new school buildings and in the renovation of  
28 existing school buildings that are required to be designed by an architect or engineer  
29 under G.S. 133-1.1, the local board of education shall participate in the planning and  
30 review process of the ~~Energy Guidelines for School Design and Construction that are~~  
31 ~~developed and maintained by the Department of Public Instruction~~ North Carolina  
32 sustainable school design protocol standards that are developed and maintained by the  
33 State Energy Office of the Department of Administration, for use by the Department of  
34 Public Instruction and shall adopt ~~local~~ energy-use goals for building design and  
35 operation that take into account local conditions in an effort to reduce the impact of  
36 operation costs on local and State budgets. In the design and construction of new school  
37 facilities and in the repair and renovation of existing school facilities, the local board of  
38 education shall consider the placement and design of windows and other building  
39 features to use the climate of North Carolina for both light and ventilation in case of  
40 ~~power-energy~~ shortages. A local board shall also consider the installation of solar  
41 energy systems or other alternative energy systems in the school facilities whenever  
42 practicable. A local board is encouraged to participate in the Green School Construction  
43 Program for the construction or major renovation of high-performance school buildings  
44 under G.S. 115C-521.2.

1 In the case of any school buildings erected, repaired, or equipped with any money  
2 loaned or granted by the State to any local school administrative unit, no board of  
3 education shall invest any money until it has (i) developed plans based upon a  
4 consideration of the State Board's facilities guidelines, (ii) submitted these plans to the  
5 State Board for its review and comments, and (iii) reviewed the plans based upon a  
6 consideration of the comments it receives from the State Board.

7 (d) Local boards of education shall make no contract for the erection of any  
8 school building unless the site upon which it is located is owned in fee simple by the  
9 board: Provided, that the board of education of a local school administrative unit, with  
10 the approval of the board of county commissioners, may appropriate funds to aid in the  
11 establishment of a school facility and the operation thereof in an adjoining local school  
12 administrative unit when a written agreement between the boards of education of the  
13 administrative units involved has been reached and the same recorded in the minutes of  
14 the boards, whereby children from the administrative unit making the appropriations  
15 shall be entitled to attend the school so established.

16 In all cases where title to property has been vested in the trustees of a special charter  
17 district which has been abolished and has not been reorganized, title to the property  
18 shall be vested in the local board of education of the county embracing the former  
19 special charter district.

20 (e) The State Board of Education shall establish within the Department of Public  
21 Instruction a central clearinghouse for access by local boards of education that may  
22 want to use a prototype design in the construction of school facilities. The State Board  
23 shall compile necessary publications and a computer database to distribute information  
24 on prototype designs to local school administrative units. A prototype design of a new  
25 school facility that is designed to at least the LEED silver standard, as defined in  
26 G.S. 115C-521.1, shall be included in this computer database. All architects and  
27 engineers registered in North Carolina may submit plans for inclusion in the computer  
28 database and these plans may be accessed by any person. The original architect of  
29 record or engineer of record shall retain ownership and liability for a prototype design.  
30 The State Board may adopt rules it considers necessary to implement this subsection."

31 **SECTION 5.** There is appropriated from the General Fund to the Green  
32 School Construction Loan Fund, as created in G.S. 115C-521.1, as enacted by Section 1  
33 of this act, the sum of one million dollars (\$1,000,000) for the 2007-2008 fiscal year and  
34 the sum of one million dollars (\$1,000,000) for the 2008-2009 fiscal year to be used for  
35 loans to local boards of education in accordance with G.S. 115C-521.1, as enacted by  
36 Section 1 of this act.

37 **SECTION 6.** G.S. 115C-521.1, as enacted in Section 1 of this act, and  
38 Section 6 of this act become effective July 1, 2007. The remainder of this act becomes  
39 effective January 1, 2008, and applies to contracts for major facility projects that have  
40 not received project approval from the Superintendent of Public Instruction prior to July  
41 1, 2008.

## About : Environmental Issues

# Top 10 Things You Can Do to Reduce Global Warming

From [Larry West](#),  
Your Guide to [Environmental Issues](#).  
FREE Newsletter. [Sign Up Now!](#)

Burning fossil fuels such as natural gas, coal, oil and gasoline raises the level of carbon dioxide in the atmosphere, and carbon dioxide is a major contributor to the [greenhouse effect and global warming](#).

You can help to reduce the demand for fossil fuels, which in turn reduces global warming, by using energy more wisely. Here are 10 simple actions you can take to help reduce global warming.

### 1) Reduce, Reuse, Recycle

Do your part to reduce waste by choosing reusable products instead of disposables. Buying products with minimal packaging (including the economy size when that makes sense for you) will help to reduce waste. And whenever you can, recycle [paper](#), [plastic](#), newspaper, glass and aluminum cans. If there isn't a [recycling program](#) at your workplace, school, or in your community, ask about starting one. By recycling half of your household waste, you can save 2,400 pounds of carbon dioxide annually.

### 2) Use Less Heat and Air Conditioning

Adding insulation to your walls and attic, and installing weather stripping or caulking around doors and windows can lower your heating costs more than 25 percent, by reducing the amount of energy you need to heat and cool your home.

Turn down the heat while you're sleeping at night or away during the day, and keep temperatures moderate at all times. Setting your thermostat just 2 degrees lower in winter and higher in summer could save about 2,000 pounds of carbon dioxide each year.

### 3) [Change a Light Bulb](#)

Wherever practical, replace regular light bulbs with compact fluorescent light (CFL) bulbs. Replacing just one 60-watt incandescent light bulb with a CFL will save you \$30 over the life of the bulb. CFLs also last 10 times longer than incandescent bulbs, use two-thirds less energy, and give off 70 percent less heat.

If every U.S. family replaced one regular light bulb with a CFL, it would eliminate 90 billion pounds of greenhouse gases, the same as taking 7.5 million cars off the road.

### 4) [Drive Less and Drive Smart](#)

Less driving means fewer emissions. Besides saving gasoline, walking and biking are great forms of exercise. Explore your community's mass transit system, and check out options for carpooling to work or school.

When you do drive, make sure your car is running efficiently. For example, keeping your tires properly inflated can improve your gas mileage by more than 3 percent. Every gallon of gas you save not only helps your budget, it also keeps 20 pounds of carbon dioxide out of the atmosphere.

### 5) Buy Energy-Efficient Products

When it's time to buy a new car, choose one that offers good gas mileage. Home appliances now come in a range of energy-efficient models, and compact fluorescent bulbs are designed to provide more natural-looking light while using far less energy than standard light bulbs.

Avoid products that come with excess packaging, especially molded plastic and other packaging that can't be recycled. If you reduce your household garbage by 10 percent, you can save 1,200 pounds of carbon dioxide annually.

## 6) Use Less Hot Water

Set your water heater at 120 degrees to save energy, and wrap it in an insulating blanket if it is more than 5 years old. Buy low-flow showerheads to save hot water and about 350 pounds of carbon dioxide yearly. Wash your clothes in warm or cold water to reduce your use of hot water and the energy required to produce it. That change alone can save at least 500 pounds of carbon dioxide annually in most households. Use the energy-saving settings on your [dishwasher](#) and let the dishes air-dry.

## 7) Use the "Off" Switch

Save electricity and reduce global warming by turning off lights when you leave a room, and using only as much light as you need. And remember to turn off your television, video player, stereo and computer when you're not using them.

It's also a good idea to turn off the water when you're not using it. While brushing your teeth, shampooing the dog or washing your car, turn off the water until you actually need it for rinsing. You'll reduce your water bill and help to conserve a vital resource.

## 8) [Plant a Tree](#)

If you have the means to plant a tree, start digging. During photosynthesis, trees and other plants absorb carbon dioxide and give off oxygen. They are an integral part of the natural atmospheric exchange cycle here on Earth, but there are too few of them to fully counter the increases in carbon dioxide caused by automobile traffic, manufacturing and other human activities. A single tree will absorb approximately one ton of carbon dioxide during its lifetime.

## 9) [Get a Report Card from Your Utility Company](#)

Many utility companies provide free home energy audits to help consumers identify areas in their homes that may not be energy efficient. In addition, many utility companies offer rebate programs to help pay for the cost of energy-efficient upgrades.

## 10) Encourage Others to Conserve

Share information about recycling and energy conservation with your friends, neighbors and co-workers, and take opportunities to encourage public officials to establish programs and policies that are good for the environment.

These 10 steps will take you a long way toward reducing your energy use and your monthly budget. And less energy use means less dependence on the fossil fuels that create greenhouse gases and contribute to global warming.

*This About.com page has been optimized for print. To view this page in its original form, please visit:*  
<http://environment.about.com/od/globalwarming/tp/globalwarmtips.htm>

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## **Public Buildings**

A formal program of, "Turn Off," monitoring, i.e., all lights, computers, printers, and fax machines that are not being used, particularly at closing.

Reduce Paper use and storage. Use recycled paper for copying

Replace incandescent light source with compact fluorescent.

LED's for signs, desk lamps and parking areas.

Minimize air conditioning. Use cross ventilation

Regular review of Electricity consumption and cost

## **Transportation**

Hybrid cars for municipal and county use

More public transportation

More bike paths, lanes and racks

Reward companies that organize car pooling and shorten the commuter routes and number of commutes by its employees

Require public school students to use the school busing system

## **Homes**

Promote an energy audit for every home owner

Arrange financing for the installation of renewable energy sources

Support green housing developments and city-based multiunit private housing

## **New Construction\***

Natural ventilation and solar lighting

Passive structural design

Heat pumps for cooling and heating

Renewable on site sources for electricity generation (solar panels)

\*Approximately five percent Additional construction cost which is recouped in lower energy cost within five years.

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A Petition  
to  
The Henderson County Board of Commissioners

William L. Moyer,	Chairman
Charlie Messer,	Vice Chairman
Chuck McGrady,	Commissioner
Larry R. Young,	Commissioner
Mark Williams,	Commissioner

From: The Henderson County Task Force on Global Warming and the appended signators

Regarding the increasingly urgent need for county government planning and the commitment of people and resources to significantly reduce ~~CO2~~ (Carbon Dioxide) emissions into the atmosphere. The resulting warming and secondary environmental effects of these emissions are now happening on a timeline measuring in years rather than in decades. Energy production from the burning of fossil fuels, principally coal, gasoline and natural gas, have been the source of the CO2. Its concentration in the air is now increasing exponentially. Government, industry, the scientific community and individual citizens will have to be informed, motivated and coordinated to implement effective plans to conserve energy and to turn quickly to renewable sources of energy that do not produce CO2.

Following is a brief outline of significant measures that may now be taken locally. They will require coordination, legislation and financial support by city, county and state government. May we be appraised of your immediate and long range plans in regard to this issue? Looking forward to your response and to working with you to mitigate this impending crisis.

Sincerely,

Dr. Stanley G. Dienst  
for The Henderson County Global Warming Task Force  
622 Rugby View Place  
Hendersonville, NC 28791

fr. Robert Armstrong

GENERAL ASSEMBLY OF NORTH CAROLINA  
1993 SESSION  
RATIFIED BILL

CHAPTER 465  
HOUSE BILL 102

AN ACT TO REQUIRE THE LOCAL BOARDS OF EDUCATION TO USE THE ENERGY GUIDELINES FOR SCHOOL DESIGN AND CONSTRUCTION AND TO REQUIRE ENERGY-USE GOALS AND STANDARDS IN ORDER TO ASSURE THE CONSTRUCTION OF ENERGY EFFICIENT NEW SCHOOLS AND SCHOOL RENOVATIONS.

Section 1. G.S. 115C-521(c) reads as rewritten:

"(c) The building of all new schoolhouses and the repairing of all old schoolhouses shall be under the control and direction of, and by contract with, the board of education in which such building and repairing is done. Boards of education shall not invest any money in any new building that is not built in accordance with plans approved by the State Superintendent to structural and functional soundness, safety and sanitation, nor contract for more money than is made available for its erection. However, this subsection shall not be construed so as to prevent boards of education from investing any money in buildings that are being constructed pursuant to a continuing contract of construction as provided for in G.S. 115C-441(c1). All contracts for buildings shall be in writing and all buildings shall be inspected, received, and approved by the local superintendent and the architect before full payment is made therefor: Provided, that this subsection shall not prohibit boards of education from repairing and altering buildings with the help of janitors and other regular employees of said board.

In the design and construction of new school buildings and in the renovation of existing school buildings that are required to be designed by an architect or engineer under G.S. 133-1.1, the local board of education shall participate in the planning and review process of the Energy Guidelines for School Design and Construction that are developed and maintained by the Department of Public Instruction and shall adopt local energy-use goals for building design and operation that take into account local conditions in an effort to reduce the impact of operation costs on local and State budgets. In the design and construction of new school facilities and in the repair and renovation of existing school facilities, the local board of education shall consider the placement and design of windows to use the climate of North Carolina for both light and ventilation in case of power shortages. A local board shall also consider the installation of solar energy systems in the school facilities whenever practicable.

In the case of any school buildings erected, repaired, or equipped with any money loaned or granted by the State to any local school administrative unit, the State Board of Education, under such rules as it may deem advisable, may retain any amount not to

exceed fifteen percent (15%) of said loan or grant, until such completed buildings, erected or repaired, in whole or in part, from such loan or grant funds, shall have been approved by a designated agent of the State Board of Education.

Upon such approval by the State Board of Education, the State Treasurer is authorized to pay the balance of the loan or grant to the treasurer of the local school administrative unit for which said loan or grant was made."

Sec. 2. This act is effective upon ratification and applies to any new or renovated school construction covered under Section 1 of this act that starts the design process after the effective date of this act.

In the General Assembly read three times and ratified this the 23rd day of July, 1993.

---

Dennis A. Wicker  
President of the Senate

---

Daniel Blue, Jr.  
Speaker of the House of Representatives

North Carolina Public Schools

# Energy Guidelines

May, 2004



*Public Schools of North Carolina*

State Board of Education  
Department of Public Instruction

Division of School Support – School Planning  
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Raleigh, NC 27699-6319

<http://www.schoolclearinghouse.org>

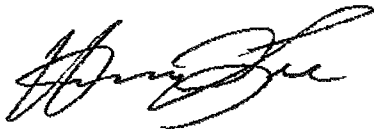
## Foreword

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The responsibility for providing public school facilities in North Carolina rests with the counties and the special chartered school districts within them. State support for school construction has been provided through state bond issues in 1949, 1953, 1963, 1973, and 1996 when it became apparent that local resources could not keep pace with growing facility needs. Local boards of education, which are the legal owners of school facilities, are responsible for planning and erecting appropriate facilities to support instructional programs.

House Bill 102 of the 1993 General Assembly Session established "An Act to Require the Local Boards of Education to Use the Energy Guidelines for School Design and Construction and to Require Energy-Use Goals and Standards in Order to Assure the Construction of Energy-Efficient New Schools and School Renovations." This bill included the following language in 115C-521 "Erection of School Buildings:" "In the design and construction of new school buildings and in the renovation of existing school buildings that are required to be designed by an architect or engineer under G.S. 133-1.1, the local board of education shall participate in the planning and review process of the Energy Guidelines for School Design and Construction that are developed and maintained by the Department of Public Instruction and shall adopt local energy-use goals for building design and operation that take into account local conditions in an effort to reduce the impact of operation costs on local and State budgets."

The North Carolina Public Schools Energy Guidelines have been developed to provide school systems and designers with useful and reliable design information to use as a basis for new schools, additions and renovations. We believe that these guidelines will enhance the ability of local school systems to plan economical and energy-efficient facilities that maximize value to their communities and provide healthy, comfortable and inviting environments for learning. It is our hope that these guidelines provide strong direction for school design, while maintaining local control of that process.



Howard N. Lee, Chairman  
State Board of Education



Michael E. Ward, State Superintendent  
NC Department of Public Instruction

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# INTRODUCTION

## **Audience**

These energy guidelines have been prepared to give the design team of architects, engineers and owner representatives' assistance as they make decisions that have an impact on the use of energy. The audience for this document may also include school board members and educational facility planners.

## **Non-Energy Considerations**

Design teams should consider school safety issues such as evacuation, emergency shelter functions, unauthorized access, vandalism, and theft when an energy conservation measure is being assessed. Questions such as the following should be considered:

- How will this ECM (Energy Conservation Measure) at this facility affect the basic functions of the school?
- If this measure or device is damaged by wind or lightning, will it disrupt normal school operation?
- Will this ECM impede proper evacuation in an emergency?
- Will this ECM allow inappropriate access to any part of the facility, such as the roof, courtyards, etc.?
- Will this strategy facilitate vandalism or provide vandals with cover?
- Can the regular operations staff maintain the equipment of this ECM? If not, is reliable service available for this product or equipment?
- How often will this equipment need service and how will that affect the normal maintenance schedule of the school?
- With the variation of climatic extremes in North Carolina, the design team needs to give careful consideration to the specific region of the state where the facility is to be constructed.
- If an ECM requires outside maintenance service, will that cost outweigh operating savings?
- When will the equipment of this ECM have to be replaced?

## **Cost**

Another critical priority is first cost. Schools must be built, operated, and maintained within an allotted budget. Design teams must weigh the first cost of ECMs against annual or lifetime savings. While ECMs reduce energy consumption and thus operating costs, they typically cost more initially than conventional practices.

## **Cost Effectiveness**

The cost effectiveness of an ECM can be evaluated in a variety of ways. Simple payback and life cycle cost analysis are two commonly used methods.

# **SCHEMATIC DESIGN PHASE**

## **Overview**

The schematic design phase is the beginning of the design process. The designer should consult with the owner to review the program described in the educational specifications and to establish project requirements. The designer should confer with consultants on the feasibility of various systems (structural, mechanical, electrical, etc.) for meeting functional and spatial requirements and any special conditions of the educational program. It is essential that consultants for site work, building systems and other related areas be involved early in the planning process.

During the schematic design phase, design teams should strive to:

- Establish financial parameters.
- Determine which ECMs will be evaluated.
- Incorporate optimal building orientation.
- Consider advantages of different building configurations.

Schematic design decisions have a lasting impact on building energy use and the effectiveness of certain ECMs. At this point in the design process, the design team should decide which ECMs are to be considered and begin to plan for their implementation.

## **Establish Financial Parameters**

Design decisions should be based on realistic financial and energy savings expectations. The energy savings data can be coupled with current utility, materials, and installation costs to establish a simple payback or life cycle cost.

During schematic design, an acceptable length of payback or other financial criteria should be established to aid the design team in selecting ECMs. When design teams have a clear idea of how much money can be allocated to ECMs and how quickly it must be recouped, selecting ECMs for a specific project will be simplified. A required period of payback may have already been established by the facilities office of the local education agency (LEA).

## **Select Energy Strategies**

To achieve the greatest success in energy conservation, design teams should select energy strategies early. Planning should certainly begin during schematic design for those energy

strategies that depend on the relationship of the building to the sun's path. For example, if the design team waits until design development to attempt to incorporate a daylighting strategy, then the basic building orientation and configuration may not support effective daylighting.

This need for early planning holds true not only for strategies related to orientation but also for items such as occupancy sensors, energy management systems, and more efficient heating, ventilating, and air conditioning (HVAC) equipment. These strategies should be selected early so that implementation, financing, and maintenance issues can be fully explored, and appropriate allowances can be made on the site plan and floor plan during schematic design.

The major energy end-uses in educational facilities are HVAC equipment and electrical lighting equipment. The rest of the consumed energy goes to other various end-uses such as water heating, kitchen equipment, office equipment, etc.

### **Building Orientation**

The objective should be to maximize daylighting potential by orienting major glazing areas to face south and north, while minimizing solar heat gains by having as little wall area and glazing as possible facing east and west. In general, an elongation of the building along the east/west axis is a wise energy choice.

In summer, east and west-facing walls and windows receive direct solar radiation for a longer period each day than south-facing walls. North and south facades receive diffused and reflected solar radiation for longer periods than the east- and west-facing walls. Diffused and reflected solar radiation causes less glare and contains less infrared radiation, or heat. Additionally, the shallow sun angles in the eastern and western skies are very difficult to shade. From an energy perspective, a good schematic site plan provides north- and south-facing glazing, limits east- and west-facing glazing, and minimizes east- and west-facing walls.

Although some perceive daylighting as costly, it can often be a very low-cost strategy when planned for from the beginning. By making the decision to orient most windows to face north and south, half of the daylighting challenge is met and costs for window shading are largely minimized.

### **Building Configuration**

During schematic design, spaces are laid out in general positions to serve educational needs. Spaces that will benefit most from daylighting on the north and south perimeters of buildings should be positioned where they can make the best use of north- and south-facing glazing. These spaces include classrooms, offices, media centers, and meeting rooms.

## DESIGN DEVELOPMENT PHASE

During the design development phase, the design team can build on the daylighting and HVAC energy-reduction schemes by focusing on the building shell: the roof, walls, windows, and exterior shading devices.

A life cycle cost analysis should be done in this phase to help select from the list of potential ECMs that were identified in the schematic design phase. By the end of this phase of the design, all ECMs should be positively identified.

As previously mentioned, the major energy end-uses are the HVAC and the electrical lighting equipment and they should be the major focuses in the life cycle cost analysis of the ECM selection process. However, smaller end-uses sometimes have a very short payback and should not be overlooked.

## CONSTRUCTION DOCUMENT PHASE

The construction document phase is the final phase of the design process where the efforts of the two earlier phases are further developed and coordinated, to the point of producing a completed set of documents ready for the bidding process.

As this further development takes place, the design team will incorporate the selected energy conservation measures in this process as plans and specifications are finalized.

The design team should continue to be keenly aware of any new technology or equipment developments that will be advantageous and compatible with the selected systems. Any new technology or other significant changes made during this phase should be thoroughly coordinated with the entire design team (and especially the owner).

## BUILDING ENVELOPE

### **Insulation**

Insulation in the building envelope is important to the overall quality and energy efficiency of the building. In particular, attention should be given to buildings that have outside walls that are framed with steel studs and provide a parallel path for heat flow between the insulation batts. According to Table A-21 in ASHRAE Standard 90.1-2001, a six-inch metal stud wall with R-19 insulation can have an effective overall R-value of only R-7.1.

In general, insulation has a positive effect on air conditioning and heating loads and results in energy savings up to a certain point, but additional insulation beyond required insulation levels has strongly diminishing returns. The most useful place to apply additional insulation is in the roof assembly, where a larger proportion of heat gain or loss occurs.

## Glazing

Selection of appropriate glazing represents a good opportunity for significant energy savings. Two important issues are pertinent: radiant (as opposed to conductive) heat gain and visible light gain. Ideally, windows would have a minimal thermal penalty and assist with lighting requirements. To accomplish this dual role, the infrared or heat portion of solar radiation must be rejected, while the visible or light portion is transmitted.

The National Fenestration Rating Council (NFRC) energy performance label can help determine how well a product will perform the functions of helping to cool a building in the summer, warm a building in the winter, keep out wind, and resist condensation. By using the information contained on the label, builders and consumers can reliably compare one product with another, and make informed decisions about the windows, doors, and skylights they buy.

NFRC adopted a new energy performance label in 1998. It lists the manufacturer, describes the product, provides a source for additional information, and includes a rating for one or more energy-performance characteristics.

NFRC rates all products in two standard sizes so that consumers and others can be sure they are comparing products of the same size. On the label, these two sizes are listed as "Res" and "Non-Res."

*U-Factor* - U-factor measures how well a product prevents heat from escaping. The rate of heat loss is indicated in terms of the U-factor (U-value) of a window assembly. U-Factor ratings generally fall between 0.10 and 1.20. The insulating value is indicated by the R-value which is the inverse of the U-value. The lower the U-value, the greater a window's resistance to heat flow and the better its insulating value.

*Solar Heat Gain Coefficient* - Solar heat gain coefficient (SHGC) measures how well a product blocks the heat that is caused by sunlight. The SHGC is the fraction of incident solar radiation admitted through a window and directly transmitted and absorbed and subsequently released inward. SHGC is expressed as a number between 0 and 1. The lower a window's solar heat gain coefficient, the less solar heat it transmits.

*Visible Transmittance* - Visible transmittance (VT) measures how much light comes through a product. The visible transmittance is an optical property that indicates the amount of visible light transmitted. VT is expressed as a number between 0 and 1. The higher the VT, the more light is transmitted.

*Air Leakage*- Air leakage (AL) is indicated by an air leakage rating expressed as the equivalent cubic feet of air passing through a square foot of window area (cfm/sq ft). Heat loss and gain occur by infiltration through cracks in the window assembly. The lower the AL, the less air passes through these cracks.

### **Window Shading**

Exterior window shading to minimize the need for interior blinds and associated reductions in available daylight should be provided. Where interior blinds are provided, use light-colored materials.

Horizontal window shades should be properly sized and provided on the south side of the building to prevent glare and localized overheating.

Light shelves on south windows should be provided for daylighting applications to project light into the building interior while blocking direct solar radiation into conditioned spaces.

Horizontal or vertical shades should be used for any large areas of east and west glazing.

### **Wall Shading**

Two different types of wall shading can be used: (1) roof overhangs and (2) shade trees. Neither decreases energy use significantly. The relative insignificance of energy savings from wall shading is not surprising, since heat conducted by the wall contributes only about 1% of the peak HVAC load. Roof overhangs are commonly considered energy savers because they block solar radiation from reaching part of the wall.

Shade trees are a long-term investment, with some risk of failure and high maintenance; however, they are beautiful and, when mature, can make a small contribution to an air-conditioning energy reduction strategy. In many jurisdictions, additional trees are required and it is worthwhile to try to position them for advantageous shading.

## **DAYLIGHTING**

Daylighting is the use of natural light for illumination within a building. Good daylighting can both reduce the energy consumption and improve the visual environment of a space.

Because so much of the energy used in a building is for the electric lighting and the cooling load that is a result of the heat given off by that lighting load, the benefits of a daylighting system can be very attractive.

A daylighting system begins with the proper orientation of the building to utilize the benefits of north- and south-facing glass and minimize the need for glazing on the east and west exposures.

Light can be introduced into the building by sidelighting, toplighting, or corelighting (courtyards or atriums).

Lights can be dimmed by using continuous dimming of fluorescent lighting. Such a dimming system is higher in first cost but is a more satisfactory installation. The lighting can account for a large percentage of the building's energy consumption and a daylighting system can help to minimize that energy consumption and its resultant cost.

The following are some general principles that should be taken into consideration in the design of a daylighting system.

- Prevent direct sunlight penetration into glare-sensitive teaching spaces.
- Provide gentle, uniform light throughout the space.
- Avoid creating sources of glare.
- Allow teachers to control the daylight with operable louvers or blinds.
- Design the lighting system to complement the daylighting design and encourage maximum energy savings through the use of automatic lighting controls. Manual controls will generally result in the artificial lights being left on most of the time.
- Plan the layout of interior spaces to take advantage of daylight conditions.
- Proper placement of automatic sensors in the space is critical.

## **SOLAR SYSTEMS**

Solar systems are not typically used in schools. However, the greatest potential for use of solar would be for solar heating of domestic hot water and for passive heating of certain spaces. More information may be obtained by contacting the North Carolina Solar Center at (800) 33NCSUN.

## **LIGHTING AND ELECTRICAL SYSTEMS**

### **General**

Design teams have three options for reducing general lighting power consumption. First, the selection of more efficient system components such as ballasts, lamps, lenses, and troffers. With this strategy, strive to achieve the highest lumen output per watt input, or efficacy, for the fixture as a unit. Second, occupancy sensors, time clocks, or some other automatic or manual controls that limit the length of time the lighting system operates is desirable. Third, mechanisms to dim electrical lighting when sufficient natural lighting is present can be provided.

Multiple switching can be provided to allow for different lighting levels for various tasks. One typical arrangement is to use a 3-lamp fixture and have one switch control one lamp in each fixture and a second switch control the other two lamps in each fixture. This allows for the availability of three levels of lighting.

Providing adequate lighting must always remain a top priority when considering innovative lighting systems, since the quality and quantity of light directly impacts the comfort and productivity of the students and instructors.

### **Fluorescent Ballasts**

All fluorescent lamps require a ballast, which is an electric device that starts and regulates power to the lamp. Electronic high frequency ballasts are now standard equipment for most fluorescent fixtures. In addition to their efficiency advantages, electronic ballasts have

minimal flicker and ambient noise and are available in a variety of ballast factor configurations, allowing the designer to “tune” light levels based on the ballast specification.

There are four ballast types:

- Instant-start ballasts have high-energy efficiency but may reduce lamp life. A standard T-8 lamp operated for more than three hours per start on an instant-start ballast will last about 15,000 hours. However, if the lamp is operated a short time each start (such as when controlled by a motion sensor), lamp life can drop to less than 5,000 hours. Choose instant-start ballasts for locations with constant light operation.
- Rapid-start ballasts are increasingly rare because they are less energy efficient and offer no significant lamp life advantages.
- Program-start ballasts are both energy efficient and significantly reduce the effect of controls and operating cycle. A standard T-8 lamp operated on a program-start ballast will last 24,000 hours at three hours per start, and premium or “super” lamps can last as long as 30,000 hours at three hours per start. Equally important, a “super” lamp operated on a motion sensor will still last over 20,000 hours. All T-5 ballasts are program-start. Choose program-start for all applications that utilize short-cycle lamp operation.
- Dimming ballasts for fluorescent lamps require an additional investment but increase lighting system performance by optimizing space appearance, occupant satisfaction, system flexibility, and energy efficiency. Dimming fluorescent ballasts should be considered in all cases requiring maximum energy performance and light level flexibility. They are particularly effective in daylit classrooms, computer classrooms, audio/video rooms, and similar spaces.

## **Lamps**

Fluorescent lamps are used to light nearly all types of school building spaces. They offer long life, high efficacy, good color performance, and low operating and maintenance costs.

There are basically three types of fluorescent lamps used in schools. T-12 lamps are still used in some older school facilities but T-12 technology is antiquated and is not to be used in any new or renovated school project. Standard T-8 lamps are by far the most common lamp used in school applications. There are also “super” and “premium” T-8 lamps that offer more energy savings than the standard T-8 lamp, but at a higher first cost. There are also T-5 lamps available for special applications, but they are not commonly used for general applications in schools.

## **Fixtures**

Standard fluorescent luminaires house between one and four lamps in a rectangular troffer. Prismatic diffusers are typically used for these troffers. The conventional design of these fixtures limits the amount of light that is distributed. A portion of the light from the top of the lamps projects up and reflects back down off the troffer top, but never makes it past the lamps. This light bounces around in the corners of the fixture and is blocked by the lamps themselves. The problem can be avoided by either allowing more free space around the



lamps (fewer lamps per fixture) or by using specular reflectors that more effectively redirect light from the top of the lamps. Specular reflectors not only reshape the interior of the luminaire, but offer an increase in fixture efficacy as well. They can work very well in older fixtures where reflective paint has yellowed due to age. Often a two-lamp regular or high-output T-8 luminaire with reflectors can be substituted for a standard four-lamp T-12 fixture. This configuration will have an increased first cost but the energy savings and lamp replacement cost should offset this quickly.

An alternative to prismatic diffusers is the use of parabolic louvers. Parabolic louvers are open grids that transmit light in a different way from prismatic diffusers. The grid spacing varies from one-half inch to several inches. Parabolic louvers tend to have a higher visual comfort probability but are not as efficient at light distribution as the prismatic diffuser. The parabolic louvers project light directly below the fixture in a distinct cone pattern, whereas the prismatic diffusers throw light in all directions. Parabolic louvers are most appropriate for rooms with computers and video display terminals, since they cause less glare than prismatic diffusers. One advantage of the parabolic louvers is that they do not trap heat in the fixture as badly as prismatic diffusers.

### **Occupancy Sensors**

Occupancy sensors employ motion detectors to shut lights off in unoccupied spaces.

Mounting configurations include simple wall box sensors appropriate for small spaces such as offices but not appropriate for classrooms. Classrooms or other larger spaces should use upper-wall corner sensors.

The sensors should be wired in series with the wall switch in classrooms so the teacher can manually turn the lights off for video presentations or other situations requiring the lights to be off.

### **Time Controls for Lighting**

Time controls save energy by reducing lighting time-of-use through preprogrammed scheduling. Time controls make sense in applications where the occupancy hours are predictable and where occupancy sensor automatic control is either impractical or undesirable. This control function can be by a central EMS control system or by simple time clocks.

### **Manual Dimmers**

Manual dimmers are the simplest of lighting control devices and serve two important functions. First, dimming lights reduces energy usage and also, with incandescent and halogen sources, there is the additional benefit of extended lamp life. Dimmers allow people to tune the lights to optimum levels for visual performance and comfort and they should be considered in classrooms, computer classrooms, office spaces and audiovisual rooms.

### **Ambient and Task Lighting**

Compact fluorescent lamps offer many advantages over incandescent lamps and are used widely for task lighting. They last about ten times as long as incandescent lamps and some

offer excellent color rendering. A 13-watt compact fluorescent lamp provides about the same illumination as a 60-watt incandescent lamp and produces considerably less heat.

One effective strategy for offices is to combine low ambient light levels with a small task light to use for reading and writing. However, this would not be practical in a classroom setting.

### **Exit Signs**

Exit signs operate 24 hours a day, 365 days a year. Some options are available that offer low energy consumption and low maintenance. Electroluminescent exit signs use no power and last for up to 20 years. They require no wiring and virtually no maintenance. LED exit signs and fluorescent exit signs also offer large savings with little maintenance and both cost less than electroluminescents. They use standard wiring, have a long life expectancy, and are typically the best alternative.

### **Lumen Maintenance**

The output of a fluorescent lamp decreases over its life due to internal degradation, as well as dust and pollutant buildup on its surface. Recognizing this fact, most lighting designers do their calculations using the assumed light output of a partially-aged lamp, usually assuming about 70 to 75 percent of the output of a new lamp/ballast/housing combination. This results in overlighting near the beginning (although lamp deterioration is more rapid at early stages than later).

The strategy of lumen maintenance is to create a desired end condition of consistent and proper light levels at the workplace by varying power levels to the ballast. Photosensor controls adjust power output to provide a constant light level, reducing power to new lamps, and increasing power later in the lifespan of the lamp. This results in lower overall power levels and corresponding energy savings over much of the life of the lamp.

### **High-Efficiency Motors**

Almost all HVAC equipment uses electric motors. For a given size, motors are available with a range of efficiencies. Standard-efficiency motors are the least efficient, high- and premium-efficiency motors are the most efficient. For a given size motor, the efficiency will not affect its output capacity but it will affect its power consumption. Where motors are in the airstream (such as with supply and return fans), specifying a high-efficiency motor reduces the electrical use and decreases the cooling load associated with that added heat. In general, replacement of existing operational motors with higher-efficiency models is not economically viable. However, when replacing a burned-out motor on an existing piece of equipment, the option of specifying a high-efficiency motor is an opportunity that should not be overlooked.

The cost effectiveness of high-efficiency motors increases with the annual hours of operation. Thus, a motor which would be barely cost effective in a light-use application could be a very wise choice in a heavier-use application. Cost effectiveness also varies with motor size, but not in a direct relationship. Rather, the mid-sized motors ranging from 3 to 25 horsepower is

the group that can show the greatest benefits from high-efficiency replacement. These motors have very short paybacks, often repaying their first-cost premium in less than one year even in light-use applications.

## **HVAC SYSTEMS AND EQUIPMENT**

### **HVAC General Recommendations**

- Verify that the mechanical systems serving each area of the school have been zoned by orientation and use patterns.
- Avoid oversizing heating and cooling equipment. In significantly daylit spaces, downsize cooling equipment to reflect daylighting benefits associated with the lights being off during peak load conditions. (When the sun is the brightest, the daylighting is at its peak usage and heat-producing lights will be turned off.)
- Install a high-efficiency air filtration system to remove particles of airborne dust. Filters should have an ASHRAE efficiency of 60% or an equivalent MERV rating of approximately 10. This will help in the improvement of indoor air quality.
- Check the design of HVAC system installations to ensure adequate access for inspections and regular housekeeping, maintenance and cleaning.
- Use building pressurization, particularly in warm, humid climates, to limit the infiltration of moist, hot outside air into the building interior. This will reduce the exposure of interior materials and finishes to moisture, thus inhibiting the growth of molds and fungi on their surfaces. It should be noted, however, that over pressurization of the building can create a problem with “pillowing” of some types of roof membranes.
- Energy can also be saved in colder climates by the pressurization of buildings.
- Provide proper air distribution to deliver conditioned air to the occupants’ work areas. The selection and location of diffusers can save energy and improve operation of the HVAC system. Select diffusers with high induction ratios, low pressure drop, and good partial-flow performance. The location of diffusers should be determined on the basis of proper airflows, rather than for the purpose of a simplistic or symmetrical pattern. The layout should take into consideration the location of furniture and partitions.
- Specify increased insulation thickness for all HVAC ductwork, piping and equipment. Minimize the amount of ductwork that is located outside of the insulated envelope of the building.
- Specify sealing of ductwork seams, joints, and connections with permanently pliable water-based mastics or sealants with a low volatile organic compound (VOC) content.
- Incorporate variable-speed, energy-efficient motors for pumps and fans, where feasible.

- Minimize long duct runs and unnecessary turns to keep static pressure losses to a minimum and, in turn, reduce the fan's energy consumption.
- Include in specifications the requirement of a building commissioning program to ensure good indoor air quality and energy efficiency as outlined in ASHRAE guidelines.
- Consider the feasibility of storage systems for chilled and hot water so that off-peak usage of electric power can be utilized where off-peak rates make it advantageous.
- Consider renewable sources of heat, such as geothermal.

### **Energy Loads**

The components, or loads, of the end-uses are those forces that induce the devices or equipment to use energy. For example, heat produced by occupants is a load on the cooling system, an end-use. Designers with a clear understanding of energy use characteristics in educational facilities can select more rewarding strategies *by targeting major end-uses and their loads*.

Targeting HVAC and lighting achieves the highest energy savings, so many ECMs are discussed in terms of their ability to reduce the consumption of these two key end-uses and their associated loads.

Selection and design of heating, ventilating, and cooling (HVAC) systems embodies complex relationships, many of which relate directly to the comfort and well being of occupants. When dealing with humidity control and ventilation, health must always take precedence over energy issues. In addition to the urgency of indoor air quality needs, engineers are faced with a wide variety of options for accomplishing that goal.

### **HVAC Loads**

Principally, HVAC systems use energy to perform four functions: provide ventilation; supply cool conditioned air; control moisture and provide heated air. The major internally generated loads that contribute to the cooling requirement are heat and moisture generated by occupants, lights, and equipment. Some of these loads can often be effectively reduced.

Heat gain from external loads include heat radiated from the sun to interior surfaces through glazing, heat conducted to the interior from exterior surfaces, and infiltration of unconditioned outside air through the building envelope. Outside air introduced as ventilation air also makes a large contribution to the air conditioning load. Air conditioning energy consumption can be reduced by either reducing these loads or selecting more efficient HVAC equipment.

The design team has two fundamental methods for achieving low air-conditioning energy consumption:

- Minimizing the HVAC loads and the size of the HVAC equipment.
- Maximizing the efficiency of the HVAC equipment.

During *Schematic Design*, the design team can plan ahead for a low-consumption HVAC system by:

- Committing to a high efficiency HVAC system.
- Committing to a low-consumption/high-efficiency lighting strategy.
- Minimizing east- and west-facing glazing.
- Committing to energy-efficient equipment.
- Planning for heat-rejecting envelope finishes and/or assemblies.
- Carefully considering an effective ventilation system.
- Specifying energy recovery systems.

### **Lighting Loads**

Educational facilities have an undeniable need for visual comfort, which is strongly influenced by the distribution and quality of light. A major portion of the electrical lighting load comes from the demand for general lighting throughout the school. Exterior lighting, task lighting, accent lighting, exit signs, and miscellaneous lighting make up the balance of the lighting load. Lighting systems typically contribute more than 50% to the overall energy budget of a school.

Lighting systems in education facilities are also among the largest loads on the HVAC cooling system, producing 15% to 20% of the peak HVAC cooling load.

When the lighting load decreases, its contribution to the HVAC cooling load decreases. This dual role in energy consumption makes lighting ECMs especially attractive. With lighting, design teams can reduce the HVAC and lighting end-uses simultaneously. The contribution of the lighting system can be minimized in the following ways.

- Minimize the run time of the lighting system.
- Maximize the efficiency of the lighting system.

During *Schematic Design*, designers can lay the foundation for reducing lighting system run time by planning for daylighting and occupancy controls. This begins with *Optimal Orientation and Building Configuration*, is developed with *Glazing Selection in Design Development*, and is completed with *Electronic Dimming Ballasts in System Design*. Even without the benefit of a well-planned daylighting scheme, high-efficiency lighting systems and automated lighting controls can produce beneficial results.

### **System Planning**

HVAC systems for educational facilities should be designed with the awareness that various portions of educational facilities may be used according to varying seasonal schedules. This, in turn, may suggest adaptation of HVAC equipment selection to meet the differing annual schedules. For instance, libraries generally require year-round space conditioning and effective humidity removal, even during vacant periods. On the other hand, the scheduling of classrooms may be more seasonal. Other spaces, such as auditoriums, are only intermittently occupied, while school administration facilities often operate for a month or more beyond the school year. Since it is not desirable to operate an entire chiller plant during the summer to solely serve a media center or administrative area, separate HVAC systems should be

considered in planning for these areas. The geographical and climatological diversity in North Carolina calls for careful consideration of ECMs that may have a short payback in one region but a longer payback in another region .

### **Fresh-Air Ventilation**

Fresh air may be introduced into the occupied space by ducting the fresh air and introducing it into the return air of the air handling unit or it may be delivered directly into the space by a separate ducted system and air-handling unit.

Fresh air introduced into the return air system may be untreated or may be required to be dehumidified in more humid climates. Fresh air systems that deliver the fresh air directly to the classrooms should always be cooled and heated.

Either system may be able to use exhaust air to temper the fresh air (and save energy) with an air-to-air heat exchanger.

### **Ventilation Rates**

Adequate fresh air must be provided to avoid indoor air quality problems. Over-ventilation will always result in high humidity problems unless costly steps are taken to control the humidity level. Good filtration (60%) can remove much of the airborne contaminants and reduce the need for dilution effects of high ventilation rates. High ventilation rates result in both higher first costs and higher operating costs.

### **Dehumidification Technology**

#### *General*

Control of indoor relative humidity (RH) is a challenging design problem. It is established that the lack of proper humidity control can lead to increased indoor air quality complaints. ASHRAE Standard 55-92 states that space humidities should not exceed 60% RH at any temperature. There are numerous strategies for controlling relative humidity while admitting more ventilation air.

#### *Conventional Systems*

Conventional AC systems primarily control the temperature and not the humidity level. As a first step, effective humidity removal using packaged and unitary equipment or fan coils critically depends on not over-sizing the equipment for the load. Energy Management Systems (EMS) allow explicit monitoring and control of space relative humidity. These should be considered, particularly where interior moisture levels are likely to be of concern. However, it should be recognized that EMS controls alone cannot mitigate humidity concerns, since humidistat control without means of reheat may over cool the conditioned space. Even so, there are several operationally related suggestions that can help to reduce moisture levels with conventional systems.

- Reducing supply air flow will decrease air coil velocity and result in increased moisture removal from the air. However, reducing the air flow to DX coils should only be done with electronic and pressure/temperature regulated coils.

- Lowering the chilled water supply temperature will increase the relative moisture removal, although it may also reduce system chiller efficiency and may require increased need for supply air reheat. This can be somewhat offset, however, by lower fan-power requirements if a variable-speed fan system is used.

### *Reheat*

Adding sensible (non-latent) heat to a system's supply air will increase the amount of time that the cooling system operates and removes moisture. Previously, the most commonly used strategy to control humidity was to use electric reheat coils for this purpose to increase the compressor run-times of thermostatically controlled constant-volume systems or with variable air volume (VAV) systems. However, reheat of previously cooled air is now prohibited by state code, except for certain applications such as with VAV systems that have reduced their air flows to the minimum setting.

### *Heat Recovery*

With chiller systems, a second condenser tube bundle can be used to capture some of the rejected heat of the compressor and then use it for heating the water loop used for reheat. One of the condenser tube bundles is piped to the cooling tower, with the other piped to the building hot water circuit. This saves energy, since the rejected heat is "free" and cooling tower operation would be reduced.

### *Central Fresh Air Units*

Outside air is drawn into a central unit that uses a direct expansion (DX) or chilled-water coil to remove humidity from the moist air prior to its introduction into the building's interior. The dehumidified air is then either introduced directly into the rooms or may be injected into the return air duct of the room HVAC units. The relative efficiency of this DX equipment may be lower than the normal cooling equipment, but saves energy since the introduced outside air is dehumidified, greatly reducing the need for dehumidification or reheat by the room HVAC units.

### *Desiccant Dryers*

Desiccant dryers generally use solid-desiccant rotating-wheel heat exchangers. Silica gel is the main solid desiccant material. Condenser heat, natural gas, solar, or other heat sources can be used to regenerate the desiccants. Such a system is sometimes used as a central fresh-air unit. The installed cost of desiccant dehumidification is very high. Other than first cost, the extensive maintenance requirements and high regenerative energy and added cooling energy expenses for desiccant dehumidifiers may make them a poor choice for use with educational facilities.

### *Total Energy Recovery System (TERS)*

A variation on a desiccant dehumidification system is the TERS, or enthalpy recovery system. The TERS consists of an air-to-air heat exchanger with a rotating wheel heat exchanger assembly. The wheel is coated with a molecular sieve desiccant coating to provide both sensible and latent heat recovery. The desiccants

remove moisture from the supply air stream while also cooling the incoming air with the exhaust air stream. Generally, the supply air from the desiccant wheel is further conditioned with additional DX or chilled-water coils prior to being added to the interior space.

A TERS has the significant advantage of producing energy savings through the transfer of sensible and latent heat between the exhaust and supply-air streams. A realistic heat recovery rate is approximately 50%-75% for both sensible and latent heat, depending on the target space temperature and relative humidity. TERS is mainly applicable for new buildings. Retrofit may be difficult due to required ducting. Maintenance costs are also likely to be elevated, a fact that should be considered in specifying such systems.

A TERS unit can be useful in maintaining good IAQ and humidity levels during the summer holiday season. This can be done independent of the main building system and save energy over running the main system. If chilled water is used, unloading on the chiller and variable frequency drives on the pumps help the overall efficiency and allow for effective use of the system at a reduced part load.

### *Run-Around Coils*

Run-around coils usually contain a water-glycol mixture with finned heat exchangers to transfer heat from the return side of the cooling coil to the supply air and thus avoid the need for reheat. Run-around coils have the advantage of being more easily retrofit onto existing systems where there may be a fairly large separation between the return and supply air sides of the cooling system. However, unlike passive heat pipes (described below), this configuration requires some pumping energy to move the liquid from one coil to the other.

### *Heat Pipe*

Heat pipes offer an attractive alternative to reheat with other heat sources, while greatly increasing the moisture removal capacity of conventional DX and chilled-water systems. Unlike TERS systems, heat pipes cannot reduce the cooling load, but only serve to increase the dehumidification potential. A heat pipe is a refrigerant-charged device with a heat exchanger at either end. One end of the coil removes heat from the incoming air stream as the refrigerant in that end is evaporated. The conventional cooling coil then has less sensible-cooling load and runs colder, removing more moisture from the pre-cooled air. The heat pipe refrigerant gas then migrates freely to the other end of the coil where it condenses, giving up heat. The condensed refrigerant then passively returns to the evaporator section by gravity or capillary action. The bypassed heat is transported by the heat pipe, condensing at its other end and reheating the chilled air without requiring any additional energy. Because the refrigerant in the heat pipe flows passively in a loop between the pre-cooler coil and the reheater coil, it requires no external power and has no moving parts. The disadvantage of heat pipes is the high initial cost.

### *Face and Bypass Dampers*

Facilities using chilled-water and constant-volume systems can provide face and bypass



dampers to reduce the need for reheat, while providing effective humidity control. With such a configuration, air dampers channel a portion of the return air (which would normally pass through the cooling coil) around the cooling coil. This results in a suitably high supply air temperature along with effective dehumidification. The system uses a draw-through air-handling unit to take advantage of the fan heat as added heat. When dehumidification is needed, the cooling coil temperature is lowered to remove additional moisture and a portion of the entering air bypasses the cooling coil to hold the discharge temperature needed to maintain the required room temperature. The result is improved temperature and humidity conditions with less need for reheat.

## **Ventilation to Accomplish Cooling Requirement**

### *Natural Ventilation*

Natural ventilation was commonplace prior to the advent of mechanical air conditioning. Detailed guidelines have been developed showing how educational facilities can be cooled with natural ventilation. Whether natural ventilation is advisable in mechanically conditioned educational facilities is a subject of debate.

Natural ventilation with operable windows has certain advantages, but one must weigh the disadvantages of increased first cost of the windows and increased potential of vandalism. There is also potential for leaving the windows open while the mechanical system is operating.

### *Economizer Cycles*

An economizer cycle is a mechanical version of natural ventilation. Economizers consist of three sets of dampers with linked controls. An exhaust damper relieves system return air to offset ventilation air brought in. An outside air damper controls the quantity of ventilation air brought into the system, and a return damper balances the return and outside air portions of the economizer. At low temperatures (below 60 degrees F), the economizer dampers adjust to the minimum ventilation setting. This reduces the cooling load while providing necessary ventilation air. At high ambient temperatures (above 72 degrees F), the dampers return to this minimum position to provide for ventilation requirements. Between these temperatures (60-68 degrees F) the economizer dampers modulate from minimum ventilation air to 100% outside air to meet cooling requirements.

Economizers can be set to operate solely based on outside temperature or they can be enthalpy economizers, which compare the enthalpy of the outside air and the return air stream to determine which air has the lower heat content. If the outside air has a lower heat content, the economizer is allowed to provide free cooling rather than run the compressors. Enthalpy economizers are most effective in humid climates.

Economizers need to be installed in accordance with code requirements, but should not be used on smaller systems or in locations where they are not required.

## Central Heating and Cooling Systems

### *Water Source Heat Pumps*

This system consists of a water-to-air heat pump in each zone, with all heat pumps interconnected by a water loop. The temperature of the water loop is kept within a limited range by a combination of a cooling tower and a heating plant. The heating plant is usually a boiler, although other types of heating plants could be used. When zones require cooling, the heat pumps reject heat to the water loop, which in turn transports the heat to a cooling tower where it is rejected to the atmosphere (when the majority of the zones are in the cooling mode). When most of the zones are in the heating mode and drawing heat from the loop, the water temperature may drop sufficiently to require heating of the loop from the boiler. During intermediate seasons, zones that are in the heating mode use the heat rejected by other zones that are in the cooling mode. The specific zone temperature is controlled by the on-off cycling of the heat pump unit. The indoor piping loop operates within a temperature range that does not require the pipe to be insulated.

### *Geothermal Heat Pumps*

The basic concept of geothermal heat pumps is to use the earth's moderate temperatures to heat and cool a building. Water heating and refrigeration can also be accomplished with geothermal. In North Carolina, ground temperatures (Fahrenheit) range from the high 50's in the mountains to the mid 60's at the coast. The earth at these temperatures serves as a good heat source and heat sink. A typical system includes a network of plastic pipe buried in the ground, a fluid (either pure water or a water/antifreeze mixture) to circulate through the pipe, a pump to circulate the fluid, water-to-air heat pumps installed in the building, and interior piping to connect the heat pumps. Heat pump units that are designed for low-temperature applications must be used.

Note: This system is more efficient and more environmentally friendly than other systems.

Listed below are some design recommendations.

- Conduct a survey at the site before the ground loop is designed. A test bore can help to determine soil properties and a test apparatus can be set up to determine soil thermal properties.

- Specify thermally fused, high-density polyethylene (HDPE) pipe for all in-ground piping.
- Avoid the use of low thermally conductive grout. Do not grout the entire bore unless it is specifically required by state or local codes. Grouting the upper portion of the bore generally provides more than adequate ground water protection. In circumstances where a bore penetrates more than one aquifer grouting to separate the different aquifers may be necessary. In this case, thermally conductive grouts may be used if they can be cost justified.
- Consult with an experienced ground-loop contractor who is IGSHPA (International Ground Source Heat Pump) certified.
- Provide adequate spacing between vertical bores to minimize long-term heat buildup effects in the field. Twenty feet is the recommended separation between bores when enough space is available. Otherwise, a system can function satisfactorily with a separation of 15 feet.
- Specify high-efficiency, single-stage heat pumps with a minimum ISO 13256-1 energy efficiency ratio (EER) of 13.0 Btu/w.h. (COP = 4.0). The economy of scale normally associated with larger units is not realized with GSHP systems. Water-to-air heat pumps larger than 6 tons (21 kw) typically have two compressors with individual refrigeration circuits. Minimal savings are realized compared to two smaller units. This discrepancy often becomes apparent when the added costs of central ductwork and the equipment room space (required for larger units) are included. Also, be careful when using two-speed units where the cooling mode dominates. While they appear to have a high rated EER, closer examination is normally necessary. Compare the high-speed cooling EER (with acceptable latent capacity) with the EER of a single-speed unit.
- Geothermal heat pump systems will blend well with modern energy management control systems. However, the system is inherently simple to control and will work well with a very simple control system.
- Avoid pumping too much water with too great a pump head. A well-designed system should only require 5 to 7.5 pump horsepower per 100 tons of cooling (11 to 16 pump watts per kilowatt of cooling capacity). These guidelines can be met by circulating 2.5 to 3 gpm per ton of peak block load.
- Use a single pump control with a minimum number of control valves. A single variable-speed pump with a differential pressure sensor across the building supply and return headers (at a location near the end of the piping) is adequate to control the system. Diverting the flow around the ground loop pays little dividend, since a balanced heat load on the water loop rarely occurs.
- Because the cooling load for a school is usually larger than the heating load in most North Carolina climates, ground fields will be sized to take rejected heat (cooling cycle)

and will be twice as big as needed for heat absorption. As such, fluid temperatures remain moderate (50s) in winter and are at low risk of freezing. Antifreeze in the circulation fluid is typically unnecessary, adds cost, and should be avoided.

### *Chilled Water/Hot Water Systems*

#### **General**

Central chilled water systems are generally used to provide cooling for a large educational facility. Most schools will need chillers in the 50-300 ton range, depending on facility size and characteristics. In choosing a chiller, select a unit with the best cooling efficiency and lowest life-cycle cost. When considering larger equipment, consider the part-load performance of cooling systems, since the facility will seldom be operating under full load conditions.

As a general rule, air-cooled chillers are more cost effective if the chiller plant is less than 300 tons. Water-cooled chillers are more cost effective above 300 tons. However, other factors, such as maintenance capabilities, may help decide the type of chiller for a particular owner.

#### **Reciprocating Chillers**

Reciprocating compressors compress refrigerant using pistons that are driven directly through a connecting rod from the drive crankshaft. There are two main types: open and hermetic reciprocating chillers. In hermetic systems, the electric motor and compressor are encapsulated in the refrigerant stream, whereas the motor is external in the open-drive configuration. One advantage to reciprocating chillers is that they are available in small sizes. Reciprocating chiller sizes vary from 15 tons to over 400 tons. Reciprocating chillers generally have lower efficiency than most other types. They are also noisy and cause vibration.

#### **Centrifugal Chillers**

Centrifugal chillers are a common larger chiller type. They often have very high full load efficiencies but generally have lower part-load efficiencies. Centrifugal compressors are usually large; sizes typically range from 100-10,000 tons.

#### **Screw Chillers**

Helical rotary or screw chillers generally have a slightly lower full-load efficiency than centrifugal chillers, but have a higher part-load efficiency at low cooling load ratios. They are also available in smaller sizes, from approximately 30 tons to 1,250 tons. Screw chillers are characteristically noisy and require acoustical isolation from occupied spaces.

#### **Gas-powered Chillers**

Natural gas-powered engines can be used as the drive for various type of open reciprocating, centrifugal and screw chillers. The performance efficiency curve for gas-driven engines is fairly flat, down to approximately 40% of the design capacity. Below this point, the efficiency drops off sharply where cylinders are unloaded to further reduce capacity below idle speed. Also, first cost and maintenance of natural

gas-fired engines are generally greater than with electrical drives.

### **Cooling Towers**

With cooling towers, water is cooled by contact with the air to reject heat from the water-cooled condensers of the chillers. Water-cooled systems using cooling towers operate at a higher efficiency than air cooled but are a higher first cost and require more maintenance.

### **Air-Cooled Condensers**

Air-cooled condensers pass outdoor air over a dry coil to condense the refrigerant. This results in a higher condensing temperature (compared to water-cooled applications) and lower performance under peak conditions. It is preferred, however, for packaged systems and unitary heat pumps due to its simplicity and low maintenance requirements.

### **Ice Storage**

Ice storage systems use refrigeration equipment at low temperature to generate ice that is stored in tanks. The ice is typically generated at night (off-peak hours) to take advantage of off-peak electrical rates. The ice is then utilized during the day, when there is a demand for cooling, by circulating a chilled water loop through the storage unit and then to the air handling unit chilled water coils.

### **Boilers**

Boilers should be sized according to the calculated heat loss and a reasonable warm-up capacity. On occasion, boilers are sized to handle future additions but, in general, they should not be grossly oversized. Extra initial cost and lower efficiency can be the result of oversizing. Boilers should be selected with efficiency ratings in accordance with the North Carolina State Energy Code. Selection of the fuel is important in minimizing operating costs. Electric boilers should not be used. Pulse combustion type boilers provide a very high efficiency and offer a variety of venting options.

The use of multiple boilers is a good choice for both energy efficiency and operational advantages. With this arrangement, the failure of one boiler will usually provide adequate heating for all but very extreme conditions.

### **Piping Systems**

As much as possible, the designer should lay out the heating/cooling components so that the piping to those components minimizes piping material and heat loss. A layout such as this that maximizes longer straight runs of pipe will save significant amounts of energy and also simplify the insulation process.

Care should be taken to provide the proper thickness of insulation, especially in more humid climates where condensation can form on the outer surface of the insulation if the proper thickness is not applied.

### **Variable-Speed Pump Drives**

Variable-speed pump drives will reduce pump motor electricity consumption in large central chilled-water systems. This is accomplished by matching pump horsepower output, relative to the actual flow requirements. A differential pressure sensor on the chilled-water line modulates the pump speed based on the pressure across a valve located two-thirds of the distance from the pumps to the farthest coil.

The pump flow rates are throttled by varying the pump output with a frequency inverter so that it becomes a variable-speed drive. Variable speed pumps can be used only on systems that use two-way control valves. Three-way valves should be placed at the ends of the system to minimize the time necessary to get chilled water to the active coils.

### **2-Pipe vs 4-Pipe**

4-pipe arrangement utilizes separate piping systems for the heating and cooling functions. Since the piping systems are separate, the option is available to cool one zone while heating another. With a 2-pipe piping arrangement, you either circulate hot water or chilled water. To change from cooling to heating or vice-versa, it is necessary to switch over the entire system.

The advantage of a 2-pipe arrangement is lower initial cost and a minimal savings in operating cost. However, there is a loss in the comfort level at times when there is a difference in relative heating and cooling requirements in the different zones. The 2-pipe arrangement is more difficult in humid climates.

The choice between these two arrangements should be made carefully, with a full understanding by the owner about the advantages and disadvantages. Consideration should especially be given to the capability of the operating personnel to monitor and properly control the 2-pipe system. A separate supplemental natural ventilation system may be necessary to maintain reasonable comfort during swing seasons.

## **Air Distribution Systems**

### ***General***

Although there are numerous variations, there are two primary types of air distribution systems for non-packaged units: constant air volume distribution systems and variable air volume distribution systems. Within these types, single-duct systems tend to be less costly and less expensive than dual-duct and multizone systems, but reheat is generally required. The VAV system is generally a more efficient type of single-duct system.

### ***Constant Air Volume Systems/Terminal Reheat***

A constant volume terminal reheat (CVTR) system cools a constant flow of mixed air to design minimum cold supply conditions, sometimes modified by an outside air reset or a discriminator. Reheat coils near each zone air diffuser provide zone temperature control. This type of system was used in the past but is now prohibited by the State Energy Code because it is reheating air that has been previously mechanically cooled. There are a few exceptions to this rule, such as in media centers where there is more of a year-round

need for humidity control.

### *Variable Temperature/Constant Volume (VTCV)*

The variable temperature constant volume (VTCV) system cools or heats a constant flow of air. Zone temperature control is achieved by modulating cooling or heating coils sequentially. Because it provides only heating or cooling and only at the cumulative rate demanded by all zones, the VTCV system is relatively energy efficient, but provides poor temperature control for individual rooms if several rooms make up a single control zone.

**Fan-Coil/Air-Handling Units** Fan-coil units are smaller units consisting of a constant volume fan, hot and chilled water coils (4-pipe system), air filters, and a ducted air distribution system. These fan-coil units typically don't offer many choices in cooling coil selection and thus are not very suitable for zones with higher latent loads.

Air-handling units are similar, but offer more choices in cooling coil selections and larger unit sizes. Economizer cycles are more common and more feasible with the larger unit sizes.

Fan-coil units and air-handling units are typically mounted remotely from the classroom areas and thus offer better noise control in the classroom. Maintenance is done away from the classroom.

**Unit Ventilators** Unit ventilators consist of constant-volume fans, hot and chilled-water coils (4-pipe system), air filters, and outdoor and return air dampers. Ventilation and/or economizer air is drawn from adjacent openings in the outside wall.

The units can be mounted in a vertical position on the floor or in a horizontal position at the ceiling. Air distribution is from a single grille on the face of the unit (non-ducted) and does not provide for very good distribution of the air within the space. Some advantages of these units are:

- There are fan energy savings as duct friction losses are avoided.
- Constant, or slowly varying, supply air temperature (through modulation of control valves).
- Good temperature control, with individual control in each classroom.

Disadvantages are as follows:

- Poor air distribution.
- Noisy, particularly for the student sitting adjacent to the unit.
- Console units take up floor space.
- Maintenance occurs in the classroom.
- Low fresh-air intakes can be polluted by mowing, vehicle exhaust, etc.
- Lubrication and adjustment of a large number of fresh-air and return-air dampers is important.

### *Variable Air Volume Reheat Systems*

A variable air volume system controls temperature within a space by varying the quantity of supply air from a central air-handling unit, rather than controlling the supply air temperature. However, as the cooling demand in a zone decreases, the air flow to it is reduced and eventually reaches a "minimum" typically on the order of 30% of the full flow rate. Reheat occurs only when this minimum air flow is reached. As zone air flow reduces toward minimum, it becomes more difficult to maintain required minimum fresh air flow unless the fresh air is delivered to the spaces through a separate duct system. Fresh air should be monitored and controlled to maintain the required minimum. VAV systems are generally considered for systems 20 tons and larger. The potential for energy savings with VAV systems is minimal when zone loads and occupancy schedules are similar (such as classrooms). VAV systems usually include economizer controls.

VAV systems with reheat do offer good potential for controlling humidity if that becomes a problem. Selection of the VAV boxes requires care to avoid radiated noise into the classrooms.

### *Fan-Powered VAV Systems*

An alternative to the simple dampered VAV reheat boxes is the fan-powered mixing box, which recirculates plenum air and mixes it with cooled primary air from the central AHU. These units can be the series type in which the fan operates at all times or the parallel type where the fan only runs when reheat is required.

One disadvantage to fan-powered systems is that the small unit fans are less efficient than a central AHU fan. The units can also be quite noisy.

### *Variable-Speed Fan Drives*

Variable-speed drives can provide important efficiency improvements to variable air volume systems by varying fan motor speeds, rather than by using variable inlet vanes or inlet cones with constant speed systems to modulate delivered air volume. Variable-speed fan motors are inverter controlled so that fan speed is adjusted dynamically as VAV boxes call for changing air volume. Variable-speed drives for VAV systems save energy and should be specified with such systems.

### *Low-Temperature Air Systems*

Low-temperature air systems have been used where, instead of 55-degree air, air at a temperature of approximately 40 degrees is circulated in the system. The low-temperature air system allows the use of considerably smaller ductwork and air handlers. Chiller efficiency may be somewhat reduced due to the low operating temperature of the water-glycol solution; however, such systems require less fan power and provide enhanced dehumidification due to the low evaporator or chilled water temperatures involved.

### *Multi-zone Systems*

The multi-zone system utilizes a central air-handling unit that has a supply and return air fan. The unit has a cooling coil (cold deck) and a heating coil (hot deck). Each supply



air zone has a pair of dampers that operate together to select the required amount of air from either the cold deck or hot deck to satisfy the cooling or heating load of that particular zone. A single duct then carries that zone's mixed air to the occupied space. This system is relatively high in initial cost but has the advantage of having all of the controlled devices at the central unit.

### *Duct Energy Losses*

Energy waste due to air leakage in ductwork and terminal devices can be considerable. All air handling systems and associated ductwork should be carefully sealed. ASHRAE estimates that ductwork installed in many commercial buildings can have leakage rates of 20% or more. The designer should strive to ensure that all system air handling equipment and ductwork is located within the insulated building envelope, if possible, and specify that the ductwork for the building be commissioned prior to occupancy and pressure tested to yield air leakage no greater than that specified.

## **Unitary Heating and Cooling Systems**

### *Packaged Terminal Air Conditioners*

A packaged terminal air-conditioning unit is generally a wall-mounted heat pump unit. They are also available as a cooling-only unit or as a cooling and gas-fired heating unit. These gas-fired units are not permitted in schools. The heat pump version of these units is generally used in mobile classroom units or in renovations where other types of systems are difficult. They typically don't control humidity well for higher ventilation rates but can be equipped with a heat wheel to help in that regard. If multiple units are used to serve a space, their operation should be staged to provide better humidity control. In general, units should never be sized larger than that indicated by approved sizing methods.

### *Split Air Conditioners*

A variation on the packaged system is the split direct-expansion system where the evaporator and condenser components are separated. There is some latitude in the choice specification of specific fan coil units for match with given condensing units. In any case, it is important the equipment not be oversized since effective humidity removal with such a system will critically depend on extended runtime. The heating source with this arrangement is either an electric duct heater, electric heater in the fan coil or a hot water coil. Generally, equipment should be chosen with a high seasonal energy efficiency ratio (SEER). The SEER should meet or exceed the requirement of the State Energy Code.

### *Split Heat Pumps*

The split heat pump is similar to the split air conditioner, except that the system has the capability to reverse the refrigerant cycle and become a heating unit. Supplementary electric heat is also included for extremely cold conditions and for the purpose of moderating supply air temperatures during the defrost cycle. Equipment should be selected with a high seasonal energy efficiency ratio (SEER) for cooling and heating seasonal performance factor (HSPF) for heating. These ratings should meet or exceed

the requirement of the State Energy Code.

### *Ductless Split Systems*

These systems consist of two matched pieces of equipment: an indoor fan coil unit and an outdoor condenser and compressor unit. The indoor unit is usually mounted high on a wall, but may also be mounted on the ceiling or above the ceiling. These systems are often used in spaces where fresh air is not provided, but they can also be installed with a fresh air duct through the outside wall.

These systems are useful where there are indoor or outdoor space constraints or may be used when there is a small space that will need cooling when it is desirable to have the central cooling system off. The systems may be cooling-only or may be heat pumps.

### *Room Air Conditioners*

In general, room air conditioners should not be used for educational facilities.

### *Gas Packs*

A gas pack is a single-packaged heating and cooling unit generally mounted at ground level on a concrete pad. These units contain a supply air fan, refrigeration cooling system and a gas-fired heat exchanger. Supply and return air ducts are extended through the outside wall to the indoor part of the air distribution system. These units are rarely used in schools.

### *Rooftop Units*

Rooftop units have been popular with some LEAs due to their low first cost and the ease with which they can be added to buildings in a modular fashion. However, many school districts prohibit their use due to maintenance issues. Fresh air is drawn from the roof area where it can pick up contamination odors and is generally hotter than other areas. This contributes to the already low efficiency. Gas-fired models of rooftop units are not recommended for school use. If it is necessary to use rooftop units, heat pumps are preferred and they should be specified with the highest efficiency available. An economizer option can be a cost effective feature for these units. To minimize noise problems, the ductwork for these units should be designed so that proper airflow can be accomplished with low fan speeds. Consideration should be given to the fact that roof leak problems tend to occur around these units due to vibration, poor flashing, and maintenance traffic around the units. Re-roofing costs are also much higher where these units are installed.

## **Energy Management Systems and Controls**

Optimal start is an option available with most energy management systems (EMS). At the beginning of the day, the energy management system determines the time at which the cooling or heating system should be activated to bring the building to comfort conditions by the time it is occupied. The time that chiller, boilers and fans are activated is based on a calculation within the EMS based on outside and inside temperatures and historic data (which the EMS accumulates) to determine the best time to activate the conditioning system. Several indoor and outdoor sensors are used. Optimal start saves energy by reducing the

system operation to the minimum time necessary to provide comfort conditions. Most new educational facilities will have an energy management system. The EMS has the capability of providing on-off control of various equipment, trend analysis reporting, electrical demand control and recording, security system interface, maintenance management, and trouble alarms.

Thermostats specified for educational facilities should be of the electronic type. These respond much more rapidly to changes in temperature than the old bi-metallic thermostats and provide finer comfort control with less variation in interior conditions. The location of control thermostats should be given careful consideration. In general, the devices should be located on interior walls away from direct air movement from diffusers.

With an EMS, teachers can be given limited set-point adjustment in the classroom without sacrificing much of the energy efficiency of the system. This can provide for more personal satisfaction in individual comfort.

One useful feature for EMS in schools is that of a pre-programmed thermostat override. Electronic thermostats are available with an override button on the face plate that allows the occupant to signal the EMS that a space is occupied and needs conditioning during periods when the space is normally unoccupied.

## PLUMBING

### **Water Heating**

Consider the feasibility of using solar water heating systems for some of the water heating needs.

Use gas-fired water heaters where possible. Electronic ignition systems should be used, rather than pilot lights.

Consider high-efficiency condensing-type water heaters where possible.

Before providing hot water to fixtures, verify that it is necessarily required at that fixture. If the LEA does not have a specific requirement for hot water, then the cost of installation and the operating cost associated with hot water can be saved.

Provide recirculation piping and pumps, keeping in mind the effect that low-water-flow fixtures have on the time to get hot water to a particular location. In some applications, a point-of-use heater may be appropriate and may save energy.

### **Insulation**

Specify water heaters that are well insulated and also consider the feasibility of an additional wrap of insulation on heaters and storage tanks.

Insulate all hot water distribution piping.

### **Fixtures**

Specify low-water-flow fixtures, in accordance with the State Plumbing Code, Table 604.4.

Use automatic lavatory faucets for all student-use restrooms, in accordance with the State Plumbing Code, paragraph 604.41.

Consider the use of waterless urinals.

### **Controls**

Consider the use of time-of-day controls on recirculation hot water pumps.

Use time-of-day controls on hot water heaters.

## **WATER CONSERVATION**

### **Overview**

Water shortages have become more critical in many parts of the state in recent years with acute drought situations. New sources of fresh water have not kept pace and voluntary or mandatory restrictions have become increasingly commonplace.

Rate structures in some municipalities have been changed to reflect a higher cost for the last gallons used. This is a reversal from what has been traditional in rate structures.

These higher costs for water use, along with an awareness of the critical nature of water shortages, have prompted a trend toward looking for ways to conserve water.

### **Water-Efficient Irrigation**

One effective way to reduce the amount of water use in an irrigation system is to preserve as much of the existing vegetation as possible, in combination with a landscape design that uses as many drought-resistant plants as possible.

Use high-efficiency irrigation technology such as drip irrigation systems, where possible. These systems deliver the water directly to the root area and waste very little of the water. Sprinkler systems, by contrast, can waste up to nearly half of the water, as the water is evaporated before it actually reaches the vegetation.

### **Rainwater Collection Systems**

In a rainwater collection system, the water is collected from roofs or ground-level surfaces and stored in a cistern. The water is then filtered and delivered to terminals by pumps. The rainwater can then be used for showers, sinks, laundries and toilet flushing.

Rainwater systems have the potential to provide 75% of the total water requirement of a school, but the payback periods are typically quite long. However, with the rising cost of water and the increased concern about the availability of water, it may be an alternative worth pursuing.

### **Gray Water Systems**

Gray water systems use untreated "used" water that has not been contaminated by toilet waste. This can include used water from showers, bathroom wash basins and water from washing machines. It does not include waste water from dishwashers or kitchen sinks.

Gray water systems typically filter, sterilize, deodorize and then recycle the used water for irrigating landscapes or flushing toilets.

### **Waterless Urinals**

Waterless urinal systems have been used in schools since 1993 and have some features that distinguish them from conventional urinal systems. The primary consideration is that the system uses no water.

The system has three main components. A polypropylene trap insert, a sealant liquid and a reinforced fiberglass urinal body. The trap cartridge "traps" the biodegradable sealant liquid, which is lighter than other liquids. The sealant liquid floats on and seals the urine from the atmosphere, allowing the urine to sink through its layer and be discharged into the drain line system.

The liquid sealant needs to be replenished on a regular basis in the trap cartridge.

### **Other Water-Use Issues**

Some school systems have eliminated dishwashers and are using disposable items.

Considerable water can be saved by washing loads of towels, etc., only when there is a full load. Also, front-loading washers use about half the water of top-loaders.