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**Resources:** Please visit the SchoolsNEXT website: Design Competition Resources, Teacher/ Mentor Resources and Additional Resources for enrichment materials.

# UNIT 2: Green Schools

## STEM and Visual Arts Connections

### To Green Schools

Grades 5-8



**LESSON TITLE:** Green Schools - Networks of Benefits

**Math Standard(s) Addressed:** logic and visual conveyance of logical progression.

**Approximate Time** Students will engage in:

**Needed for**

**Lesson:**

30 – 45 min.

independent activities

cooperative learning

peer tutoring

visuals

pairing

hands-on activities

centers

lecture

whole group instruction

technology integration

creating a project

guest speakers

**Class Starter:** Ask students if they have ever heard of a “green school.” What is a LEED school? (See attached Fact Sheet.) Brainstorm features of green schools. Distribute and read aloud the Fossil Ridge High School case study (provided). Discuss the elements of Fossil Ridge that are “green.” Work as a class to define the following terms: green building, daylighting, natural ventilation, low emitting materials, indoor air quality, productivity, teacher retention.

**Objectives:** Students will consider the network of benefits that result from high-performance, green design features in school buildings.

**Materials:** 3 pieces butcher paper (or poster board)  
Markers  
Printouts of supplemental materials

**Step-By-Step Procedures:**

- Have students break into 3 groups. Assign a green school design feature to each group:
  1. larger windows (increased daylighting): green highlighted text
  2. operable windows (increased natural ventilation): orange highlighted text
  3. low-emitting materials and finishes (improved indoor air quality): blue highlighted text.
- In groups, review the appropriate sections of “Greening America’s Schools: Costs and Benefits” by Gregory Kats. A color-coded, highlighted version of this document has been provided to draw students’ attention to relevant topics (see color assignments above). Every group should read text highlighted in yellow. Save paper – print one copy of the study per group and have students take turns reading aloud.
- Distribute butcher paper. Have students work together to create a web that visually illustrates the benefits that stem from their assigned green building feature.
  - Ex: larger windows -> more daylight -> students can concentrate -> faster learning -> increased test scores
- Bring groups together to share results. What are the common themes? What are some of the possible benefits to students and teachers who occupy green schools?

**Guided/Independent Practice:**

Teacher may want to assign “Greening America’s Schools” as pre-reading. An unmarked copy of the study is available for free at [www.usgbc.org/leed/schools](http://www.usgbc.org/leed/schools) under “Research Studies on Green Schools.”

**Assessment:** Based on the readings, ask students to brainstorm other potential green school features. Green schools are healthy for occupants and healthy for the environment and answers should reflect both of these principles. Examples include: solar panels, green roofs, energy efficient lighting, recycled materials, alternative fuel school buses and water efficient sinks and toilets.

**Differentiation Ideas:**

- Select one green school feature and work as a class create a web.

**Adaptations & Extension Ideas:**

- Have students create webs on the computer using “Inspiration.” A free 30 day trial of this software can be downloaded at [www.inspiration.com/freetrial](http://www.inspiration.com/freetrial).
- Have students research green schools online. Is there a green school in your state?

**Closure:** Discuss how some green schools features or practices might be incorporated into your school. What are some simple things your school could do to be more green? Examples include: cleaning with non-toxic products, replacing standard light bulbs with compact fluorescents, turning off computers and lights when not in use and recycling.



# STEM and Visual Arts Connections To Green Schools

Grades 5-8



## LESSON TITLE: Meeting Community and School Needs

**Math Standard(s) Addressed:** Organizing information in a logical manner (i.e., Venn Diagrams, T-charts).

**Approximate  
Time Needed for**

**Lesson:**

30 – 45 min.

**Students will engage in:**

- |   |  |  |
|---|--|--|
| <input type="checkbox"/> independent activities | <input type="checkbox"/> pairing             | <input type="checkbox"/> whole group instruction |
| <input type="checkbox"/> cooperative learning   | <input type="checkbox"/> hands-on activities | <input type="checkbox"/> technology integration  |
| <input type="checkbox"/> peer tutoring          | <input type="checkbox"/> centers             | <input type="checkbox"/> creating a project      |
| <input type="checkbox"/> visuals                | <input type="checkbox"/> lecture             | <input type="checkbox"/> guest speakers          |

**Class Starter:** Have a class discussion on how the school can help the community. List ideas generated by the students on the board. Discuss realistic ideas and how students could gather more information to help decide if the idea is desired by the community and a viable option in the design of the new school.

**Objectives:** To identify ways to involve the community in the new school design.

**Materials:** Paper and Pencil  
Drawing Paper  
Whiteboard  
Markers/Crayons/Colored Pencils

**Step-By-Step Procedures:**

- Help students compare/contrast the ideas generated for involving the community in the design of the new school.
- Invite a guest speaker from the community, such as a local realtor (contact the National Association of REALTORS®), local government representative, business leader, developer.
- Have students interview the guest about what the community, new and current residents, want to see in their local community/school. Or have students write a letter to a local community leader asking similar questions.
- Organize the information using a graphic organizer (i.e., Venn Diagram, T-chart).

**Guided/Independent Practice:** Students design interview questions/gather information on ideas.

**Assessment:** Design a public service announcement poster sharing how the community and school support each other in the new design of the school.

**Differentiation Ideas:**

- Work in pairs or small cooperative groups
- Create a video, song, or poem about the ideas for involving community in the new school

**Adaptations & Extension Ideas:**

- Conduct a survey and poll community, have a debate on the pros/cons of the various ideas, or hold public town meetings on how the community and school environments can support one another in the new school design.

**Closure:** Select one or two ways in which the community can be involved in the new school and include the details in the new school model.

**Connections to other Content Areas:** Public Speaking, Art, Communications (letter writing, interview questions)

**Additional Resources:** *Schools for Successful Communities: An Element of Smart Growth*, CEFPI, 2004, [www.cefpi.org](http://www.cefpi.org), 480-391-0840  
**Useful Web sites:** <http://www.realtor.org/SG3.nsf/Pages/winter2005?OpenDocument>  
<http://www.realtor.org/SG3.nsf/Pages/oldneighborhoods?OpenDocument>  
<http://www.realtor.org/SG3.nsf/Pages/oldneighborhoods?OpenDocument>



# STEM and Visual Arts Connections To Green Schools

Grades 5-8



**LESSON TITLE: Space Conservation**

**Math Standard(s) Addressed:** Uses a variety of strategies to understand problem situations and processes

**Approximate  
Time Needed for**

**Lesson:**

30-45 minutes

**Students will engage in:**

- |   |  |  |
|---|--|--|
| <input type="checkbox"/> independent activities | <input type="checkbox"/> pairing             | <input type="checkbox"/> whole group instruction |
| <input type="checkbox"/> cooperative learning   | <input type="checkbox"/> hands-on activities | <input type="checkbox"/> technology integration  |
| <input type="checkbox"/> peer tutoring          | <input type="checkbox"/> centers             | <input type="checkbox"/> creating a project      |
| <input type="checkbox"/> visuals                | <input type="checkbox"/> lecture             | <input type="checkbox"/> guest speakers          |

**Class Starter:** Conduct a class discussion concerning definitions and reasons for space conservation (i.e., no unused land available). Give examples of buildings in large cities. Have students work in small groups. Invite an engineer or environmental engineer to speak to class.

**Objectives:** To be able to design buildings using allotted amount of area.

**Materials:** paper pencil

**Step-By-Step Procedures:**

- Consider the task of creating an environmental park.
- Solve the problem present in the most cost effective, creative way you can while creating an environment the community will be proud to have built.
- Consider tangible/intangible architectural qualities when completing this task.

**Guided/Independent Practice:** Model ability to use of space in creation of an environment.

**Assessment:** Completion of project being turned in for review after sharing with class.

**Differentiation Ideas:**

- Have students work in pairs sharing jobs if groups become too difficult in which to work.

**Adaptations & Extension Ideas:**

- Students will create a park using as many elements that they want creating their ideal environmental park.

**Closure:** Share and discuss all drawings and products concentrating on usage of resources, costs, and design features.

**Connections to other Content Areas:**

**Additional Resources:**

Dale Seymour publication Spaces Solving Problems of access to careers in Engineering and Science;  
<http://www.realtor.org> ; <http://www.healthyschools.org> ; <http://www.planning.org>  
<http://www.epa.gov>



**FOSSIL RIDGE HIGH SCHOOL  
FORT COLLINS, COLORADO**

**60%** more energy efficient

**\$11,500** in annual water savings

**\$0** additional cost for LEED

**LEED® Facts**

*Fossil Ridge High School  
Fort Collins, CO*

*LEED for New Construction  
Certification awarded July 12, 2005*

**Silver 36\***

**Sustainable Sites 7/14**

**Water Efficiency 1/5**

**Energy & Atmosphere 13/17**

**Materials & Resources 5/13**

**Indoor Environmental Quality 5/15**

**Innovation & Design 5/5**

*\*Out of a possible 69 points*

## FOSSIL RIDGE HIGH SCHOOL

# Energy Savings = Classroom Spending

## PROJECT BACKGROUND

When building a new high school in Fort Collins, Colorado, Poudre School District's primary goal was to provide students with the healthiest, most comfortable learning environment possible. Poudre also wanted the school to be flexible and adaptable; to make it a teaching tool for environmental stewardship; and to build it for no added cost. To achieve these goals, the district chose to pursue LEED® certification for the new Fossil Ridge High School. The result is a state-of-the-art, 290,000-square-foot building with capacity for 1,800 students—all of whom will learn in an environmentally responsible, healthy building that's saving the school district money.

## ENERGY SAVINGS EQUAL CLASSROOM SPENDING

Poudre had built two high performance schools in the past, but wanted LEED certification for Fossil Ridge because of the added benefits of third-party validation. LEED gave the district confidence that its new school would perform as expected, and enabled the district to benchmark the building's performance. LEED also helped justify green practices by demonstrating to building operators how their actions can have a positive impact throughout the building.

Like all school districts, Poudre has to make decisions based on a tight budget. LEED delivered a higher quality building for no added cost: at \$179 per square foot, including design fees, furnishings and equipment, Fossil Ridge's cost compares favorably with other school building projects in the region. And that doesn't include the significant savings from reduced water and energy use. "Fossil Ridge's energy bills will be about one-third less than the newest high school in the district of the same size," said Stu Reeve, energy manager for the district. "And the dollars saved go right back into the classroom."

## STRATEGIES AND RESULTS

Poudre's success was a result of involving not just architects and engineers, but also teachers, maintenance staff, and others from the very beginning. Making sure that everyone at the school was committed to achieving LEED goals helped the project team build a school that met the district's goals for student health, operating efficiency, and environmental stewardship, at no additional cost.

Many studies show that natural lighting improves students' reading and math scores, so the team focused on daylighting strategies such as placing windows on multiple sides of classrooms, roof monitors, and Solatubes to bring light into interior spaces. Superior indoor air quality is also a primary concern for schools, so the building features operable windows to let in fresh air; carbon dioxide sensors; and paints and furnishings with low volatile organic compounds (VOCs).

Fossil Ridge is 60% more energy efficient than comparable buildings because of innovative measures including lighting occupancy sensors; connecting HVAC coils to occupancy; and heat wheels for heat recovery. Ice is made and stored during off-peak nighttime hours to cool the building during the day, and energy use is offset by wind power purchases. Water conservation is a key concern across Colorado, so Fossil Ridge uses a raw water pond for campus irrigation; installed low-flow faucets and toilets; and has artificial turf for the athletic field.

The project team saved fuel and transportation costs by using regionally manufactured materials whenever possible, and gave priority to products with high recycled content. Nearly 75% of the construction waste was diverted from landfills through recycling. Fossil Ridge is also a living educational tool, showing the next generation the importance of environmental stewardship and how it can be achieved.

## ABOUT POUDE SCHOOL DISTRICTS

The Poudre School District comprises 45 schools and nearly 22,500 students around the city of Fort Collins, Colorado. The District has won awards for outstanding student test scores and graduation rates, and strives "to support and inspire every child to think, to learn, to care, and to graduate prepared to be successful in a changing world."

"Building a LEED certified school is the right thing to do, the right thing to teach kids, and the right message to send to the community. And it doesn't cost more."

Michael Spearnak  
Poudre School District



**Owner:** Poudre School District  
**Architect:** RB+B Architects  
**Contractor:** Haselden Construction, Inc.  
**Project size:** 290,000 square feet  
**Total Project cost:** \$179 per square foot; \$28,889 per student

Photography courtesy of RB+B Architects, Inc.

## ABOUT LEED

The LEED® Green Building Rating System™ is the national benchmark for the design, construction, and operations of high-performance green buildings. Visit the U.S. Green Building Council's Web site at [www.usgbc.org](http://www.usgbc.org) to learn more about how you can make LEED work for you.



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[www.usgbc.org](http://www.usgbc.org)  
202 828-7422



EPA's Indoor Environments Division's (IED) Indoor Air Quality Tools for Schools released [the School IAQ Assessment Mobile App](#). The mobile app was developed to assist schools and school districts with performing comprehensive indoor air quality (IAQ) facility assessments to protect health and improve performance of children and staff. The [School IAQ Assessment mobile app](#) is a "one-stop shop" for accessing guidance from EPA's *Indoor Air Quality Tools for Schools* Action Kit and the Framework for Effective IAQ Management. The mobile app will provide school district and industry working with schools an efficient, innovative technology integrated with proven strategies for addressing critical building-related environmental health issues such as ventilation, cleaning and maintenance, mold and moisture control, environmental asthma triggers, material selection, radon, and integrated pest management.

This new tool will help you conduct comprehensive indoor air quality (IAQ) facility assessments. The [School IAQ Assessment Mobile App](#) is now available—free of charge—to complement an existing IAQ management program and serve as the foundation for IAQ management in your district. A school walkthrough is an essential component of a comprehensive IAQ management program. Just like going to the doctor for your check-up, conducting school facility assessments should be part of your preventative care plan. Prevention saves time and money in the long run. This new School IAQ Assessment Mobile App will help you identify, prioritize and resolve IAQ issues.

**With this new FREE app you can—**

- Access the *IAQ Tools for Schools* Action Kit guidance.
- Complete 11 school IAQ assessment checklists, organized by school area (e.g., building and grounds maintenance, teacher's classroom, HVAC, new renovations).
- Submit the completed checklist assessment forms (in Excel format) to a designated IAQ coordinator.
- Attach pictures and add notes about IAQ problems to your completed checklists.

# Energy Savings Plus Health:

## Indoor Air Quality Guidelines for School Building Upgrades



[http://www.epa.gov/iaq/schools/energy\\_savings\\_plus\\_health.html](http://www.epa.gov/iaq/schools/energy_savings_plus_health.html)



**THE CENTER  
FOR GREEN SCHOOLS**



**2013**

**STATE OF OUR  
SCHOOLS  
REPORT**



# PREFACE FROM RICK FEDRIZZI + RACHEL GUTTER



Fewer subjects in American life elicit more hand-wringing and finger-pointing than the state of our public schools. We complain that administrators and policymakers meddle too much, that teachers are disempowered, that parents are disengaged and that students are disinterested. We regularly decry the teach-to-the-test mentality and outdated curricula that fail to prepare the students of today for the opportunities of tomorrow.

We've spent so much time spinning our wheels over how to fix the *who* and the *what* of education, we've ignored what needs to be done to fix the *where*. Not only are the places where our children learn vitally important to a quality education, but improving those places is something we know how to do.

We know how to increase energy and water efficiency to save taxpayer dollars and put money back into the classroom where it belongs. We know that increasing daylight, optimizing acoustics and improving indoor air quality will enhance our children's ability to learn and our teachers' ability to teach.

Although we know how to repair the crumbling infrastructure of our nation's schools, we don't know where to begin, nor do we understand the full scope of the problem. The fact is, it has been a whopping 18 years since the U.S. government took a comprehensive look at the physical condition of the nearly 100,000 primary and secondary public schools in our country. We can't continue to ignore a problem just because we don't understand the extent of it.

In this first annual State of Our Schools report, our best guess is that it will take approximately \$271 billion to bring school buildings up to working order and comply with laws. If we add to that modernization costs to ensure that our schools meet today's education, safety and health standards, we estimate a jaw-dropping \$542 billion would be required.

We need more precise, more detailed and more accurate information to direct our efforts to restore, repair and revive our schools. That's why the Center for Green Schools at the U.S. Green Building Council, along with our partners, is calling for an updated survey on the condition of America's schools. A clear understanding of the current state of educational facilities would allow us to direct our limited dollars to where they are needed most, ensuring that all of our children have the opportunity to attend a school that is healthy and safe, and one that enhances their ability to learn, grow and thrive.



***Rick Fedrizzi***  
President, CEO and Founding Chair  
The U.S. Green Building Council



***Rachel Gutter***  
Director  
The Center for Green Schools at  
the U.S. Green Building Council

# FOREWORD FROM PRESIDENT CLINTON

Since I first became governor more than 30 years ago I have visited countless schools, and I know that where our kids learn is critical to their success. That's why, as President, I prioritized classroom modernization, renovation and new construction with several key initiatives — including the release of a Government Accountability Office report that was the first comprehensive federal assessment on the state of our school buildings since 1965.

The report, *School Facilities: Condition of America's Schools*, began a national conversation with governors, mayors, state legislators, and local officials on the importance of safe, healthy and energy-efficient classrooms. We also released *Schools as Centers of Community: A Citizens' Guide For Planning and Design*, a report still used today, and we created the National Clearinghouse for Educational Facilities with funding from the Department of Education.

Yet nearly 20 years later, in a country where public education is meant to serve as the “great equalizer” for all of its children, we are still struggling to provide equal opportunity when it comes to the upkeep, maintenance and modernization of our schools and classrooms.

Through the work of organizations like the Center for Green Schools at the U.S. Green Building Council, the American Federation of Teachers, the American Lung Association, the National Education Association and the National PTA, there are forward-looking, sustainable and affordable solutions well within our grasp—and it's time to act. Every day we let pass without addressing inefficient energy practices, poor indoor air quality, and other problems associated with unhealthy learning environments, we are passing up tremendous opportunities.

Today, school districts can make significant infrastructure improvements with little to no upfront cost to their communities—improvements that will free up critical dollars for more teachers, computers, or textbooks. And the schools that undergo retrofits will be improving their learning spaces while creating jobs and supporting local economies.

I hope everyone who is interested in the state of American public education reads this report from the Center for Green Schools, and that you will join us as we transform long-term challenges into new opportunities. I'm optimistic that by working together, we can give our children the best possible education and make America the world's greatest innovator for generations to come.



**President Bill Clinton**

# LETTER TO CONGRESS

## Call for GAO Study on America's School Facilities

**Chairman Tom Harkin**

U.S. Senate Committee on Health, Education,  
Labor and Pensions  
428 Dirksen Senate Office Building  
Washington, D.C. 20510

**Ranking Member Michael Enzi**

U.S. Senate Committee on Health, Education,  
Labor and Pensions  
835 Hart Senate Office Building  
Washington, D.C. 20510

**Chairman John Kline**

U.S. House Committee on Education and  
the Workforce  
2181 Rayburn House Office Building  
Washington, D.C. 20515

**Ranking Member George Miller**

U.S. House Committee on Education and  
the Workforce  
2101 Rayburn House Office Building  
Washington, D.C. 20515

*Dear Chairmen and Ranking Members:*

*January 14, 2013*

We write today to ask for your help in requesting a new Government Accountability Office (GAO) study on the condition of America's school facilities.

The last comprehensive report on America's school facilities was conducted by GAO in 1995 (GAO/HEHS-95-61), with portions updated in 1996. This report highlighted the dire need to improve our school facilities, including the fact that 15,000 U.S. schools were circulating air that at the time was deemed unfit to breathe. The anecdotal data and less comprehensive reports issued since the 1995 GAO study have suggested that our nation's educational facilities are continuing to deteriorate without proper maintenance, and that the comprehensive understanding of the current conditions of our nation's educational facilities is lacking. At the time of the 1995 GAO report, it was estimated that our nation's schools needed approximately \$112 billion dollars to be brought to sound overall conditions. Some estimates now put that figure three times higher. Without this information, adequate resources cannot be properly planned for or prioritized to address this critical issue.

While many have been dedicated to improving learning spaces for our children since the last comprehensive federal report, too many of our nation's schools are still compromising our children's ability to learn. The results from a new GAO study on the condition of our school facilities would greatly benefit the hard work of school districts, teachers, parents and organizations around the country toward ensuring that every child can learn in a safe, efficient school within this generation.

We look forward to working with you to issue a new GAO report. Please contact any of our organizations if we can provide additional information to help advance this request.

*Signed by,*

21st Century School Fund / American Architectural Foundation / American Federation of Teachers / American Institute of Architects / American Institute of Architects Committee on Architecture for Education / American Lung Association / American Society of Civil Engineers / American Society of Landscape Architects / ASHRAE / BlueGreen Alliance / Campaign for Environmental Literacy / Council of Educational Facilities Planners International / Evangelical Environmental Network / Healthy Schools Campaign / National Wildlife Federation / Healthy Schools Network, Inc. / International Association of Sheet Metal, Air, Rail and Transportation Workers (SMART) / National Association of School Nurses / National Association of State Energy Officials / National Education Association / National Education Association Health Information Network / National PTA / National School Supply and Equipment Association / U.S. Green Building Council

## 2013 STATE OF OUR SCHOOLS

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Elementary and secondary public schools are centers of nearly 100,000 communities across the United States, yet American citizens and public officials have a poor understanding of the scale of this infrastructure and its condition. School districts often find themselves in the precarious position of having to choose between curricular resources and facility resources, without adequate information to make informed decisions.

Policymakers, parents, educators and taxpayers need to know the state of public school facilities and the extent of the deferred maintenance and capital construction needs of our school districts. We must account for the assets and liabilities associated with the management, planning, design, construction, operation and maintenance of school buildings and grounds.

The federal government can assist our educational system at the national, state and local levels by helping to paint a more complete picture of the scale and scope of our school facilities. By collecting current, comprehensive and comparable school building data, we can become more responsible stewards of our public school facilities. Good information will enable us to make sound fiscal decisions about this important community infrastructure. With greater knowledge and understanding, school districts will be better able to provide the quality public school facilities needed to prepare young people to become active contributors to their communities and productive members of society.

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## THE SCALE OF K-12 PUBLIC SCHOOL FACILITY INFRASTRUCTURE

In the fall of 2012, about 50 million students attended nearly 100,000 public elementary and secondary schools in public school buildings throughout the United States.<sup>i</sup> There is neither national nor comparable state-by-state data on the most basic information about these public school facilities. While some states maintain information on their school facilities, a publicly accessible inventory of the age, number or size of public school buildings and sites does not exist nationally or by state. This information is often difficult to access publicly at the school district level as well.

*“ In 1999. . . the average age of the nation’s main school buildings was 40 years old— putting the average date of construction for our nation’s schools at 1959.”*

As a result, “independent, smaller-scale studies” have been conducted to assess the current state of the nation’s K-12 public facility infrastructure. In 1999, the National Center for Education Statistics surveyed a sample of school districts and estimated that the average age of the nation’s main school buildings was 40 years old—putting the average date of construction for our nation’s schools at 1959.<sup>ii</sup>

In 2008, the 21st Century School Fund estimated the nation’s K-12 public school building space at 6.6 billion square feet. This estimate was developed by multiplying the total enrollments at public elementary and secondary schools by the national average building size per student. Using a similar approach, a conservative land area estimate was calculated at more than 1 million acres of public school land.<sup>iii</sup>

Another way to appreciate the scale of K-12 facility infrastructure is through its replacement value and the ongoing operating and capital expenditures of school districts and states for school facilities. The replacement value of the nation’s K-12 public school facilities in 2008 was estimated at \$1 trillion.<sup>iv</sup> For the 2008-2009 school

year (Fiscal Year 2009), school districts spent a total of approximately \$50 billion for the operations and maintenance of their facilities.<sup>v</sup> The Environmental Protection Agency estimated in 2008 that approximately \$8 billion of this \$50 billion was for utilities.<sup>vi</sup>

According to the U.S. Census of Governments, from 2005-2008, school district capital outlay for new construction, major building improvements and building and land acquisition averaged \$52 billion a year. For the 10 years prior, 1995 to 2004, the U.S. Census of Governments reported \$304 billion (2005 dollars) of capital outlay for school construction, major building improvements and building and land acquisition.<sup>vii</sup> Analysis of project level data from 1995-2004 found that 41 percent of the total school district project spending was for entirely new building construction. Only 24 percent was spent on existing buildings alone, and 35 percent was spent on work that included both building additions and improvements to existing buildings.<sup>viii</sup>

## THE CONDITION OF K-12 PUBLIC SCHOOL FACILITIES

Without even a basic inventory of public school facilities, it is difficult to know the condition of the nation’s public school buildings and grounds. However, in the absence of a comprehensive public school facility infrastructure inventory, there are ways to piece together a reasonable estimation of the condition of our public school facilities.

One way to assess the condition of school facilities is to estimate the cost of bringing the facilities into good repair. A school facility is in a state of good repair when it operates as it was intended when it was first built. This is a low threshold for school conditions. For example, if a school was built with only one electrical outlet in each classroom, “good repair” just means that these outlets are operable and safe. Good repair does not include the cost for modern use of the building—for example, the cost of adding more outlets in each classroom to support standard educational equipment and the cost of an electrical service upgrade to support higher electrical load demands of modern schools.

The last comprehensive survey and study of the condition of our nation's public schools was conducted by the Government Accountability Office (GAO; formerly General Accounting Office) 18 years ago, in 1995. At that time, the GAO found \$112 billion was needed to bring the nation's existing public schools into good repair and eliminate deferred maintenance of major building components, systems and finishes.<sup>x</sup> This \$112 billion did not include the cost of any new construction for enrollment growth, nor did it include any estimates of the cost to modernize public school facilities for educational purposes, such as for early childhood expansion, special education inclusion or for integrating technology into instruction.

Using the survey from the 1995 GAO study, the National Center for Education Statistics surveyed a representative sample of school districts in 1999 on the condition of their school facilities and estimated that the deferred maintenance needs had grown by \$15 billion in four years, to \$127 billion.

A 2008 study by the 21st Century School Fund used a building industry best practice method to estimate deferred maintenance in the nation's public schools. It compared what school districts had spent since the 1995 GAO study and what they should have been spending to maintain school facilities in good repair. Based on American School

*"The last comprehensive survey and study of the condition of our nation's public schools was conducted by the Government Accountability Office (GAO) 18 years ago, in 1995."*

and University's *Annual Maintenance & Operations Cost Studies For Schools* and project start data collected by McGraw-Hill Construction, it is estimated that school districts spent about \$211 billion for maintenance, repair and capital renewals between 1995 and 2008 (in 2008 dollars). However, using a 50-year depreciation schedule for keeping facilities in good repair, school districts should have spent about \$482 billion to keep the existing school buildings and grounds in good repair. So while school districts spent more than the \$112 billion GAO estimate, the ongoing obligations of maintaining, repairing and renewing facilities that serve more than 50 million people daily grew; and in 2008, there was \$271 billion of deferred maintenance.<sup>x</sup> This deferred maintenance "deficit" represents an estimated \$41 per square foot of building space, or \$5,450 per student to bring the nation's public schools into good repair.

As noted, however, bringing schools into good repair does not address the critical need to modernize facilities to meet current health, safety and educational standards. Estimates for the cost of both bringing schools into good repair and addressing modernization needs are much higher. If schools were to be modernized on a 25-year lifecycle—a defensible schedule, given rapid changes in building technology, educational demands and population change — \$542 billion would be required over the next 10 years to modernize our Pre-K through 12th grade educational infrastructure.<sup>xi</sup> Again, this would not include new construction to accommodate enrollment growth.



## THE QUALITY OF K-12 SCHOOL FACILITIES

While the basic condition of school buildings and grounds is important, an adequate school facility is more than just a building that is in good repair. A school facility needs to be safe, healthy, educationally appropriate and environmentally sustainable. Public schools must be affordable but should also be a source of civic pride. A growing body of research is helping to clarify the impact that school facility planning, design, construction, operations and maintenance can have on safety, the environment and our communities.

### FACILITIES AND STUDENT BEHAVIOR

Researchers have found a relationship between various aspects of the physical environment and problematic student behavior in high schools.<sup>xii</sup> In examining a “broken-windows” theory of physical disorder in schools, researchers found a direct association between physical disorder and social disorder in schools and suggest that the physical disorder may operate through increased fear and decreased collective efficacy to affect perceptions of threats or violence.<sup>xiii</sup>

### FACILITIES AND HEALTH

School facilities can affect occupant health—that of both children and adults. A review of an array of studies found that air quality, acoustics, levels of thermal comfort and levels of daylight affect the stress levels, health and well-being of occupants in schools.<sup>xiv</sup> Public health research has shown that respiratory health and air pollutants are strongly related. The understanding of the direct connection between indoor air quality and Sick Building Syndrome has also become well-established.<sup>xv</sup>

*“Homebuyers value good quality school facilities, even without knowledge of the research evidence. A 2010 study of the impact of public school facility bond passage on home prices found buyers were willing to pay immediate and sizable increases in home prices.”*

Researchers have found that increased ventilation rates are, on average, associated with fewer adverse health effects, with superior work and school performance and with lower rates of absenteeism. A clear increase in respiratory illness occurs with the very low ventilation rates that have been found in some schools.<sup>xvi</sup> Teachers in Washington, D.C. and Chicago reported missing an average of four days annually because of health problems caused by adverse building conditions (with poor indoor air quality cited as the biggest problem).<sup>xvii</sup> Substitute teacher costs for these absences alone would total \$1.5 and \$9 million dollars, respectively.

### FACILITIES AND EDUCATION

Through ongoing research into the interaction between the design and condition of school buildings and the teaching and learning happening within, we are gaining a clearer understanding of the power of the facility to inhibit or enhance teaching and learning. Studies have found that higher levels of student achievement, controlled for socio-economic status, are associated with better quality facility design and condition.<sup>xviii/xix</sup>





In one such study of teachers' perceptions of facility conditions in their schools, researchers found that teachers are more likely to stay in schools and continue teaching careers when they are in facilities that they rate as being in good or excellent condition.<sup>xx</sup> School location and siting can also have an impact on teaching effectiveness and student performance. In another study, researchers found that in one school located in the regular flight path of an airport, with controls for socio-economics and other factors, students performed as much as 20 percent lower than their peers on reading tests, which the researchers attributed to the high levels of noise.<sup>xxi</sup>

## FACILITIES AND COMMUNITIES

School facilities not only affect the students, staff and other daily users of the buildings and grounds, but they also affect our communities and the larger environment within which they are located. The environmental effects of school facilities are a function of where schools are sited, their size, the sustainability of their design and the efficiency of their operation and use.<sup>xxii</sup>

Homebuyers value good quality school facilities, even without knowledge of the research evidence. A 2010 study of the impact of public school facility bond passage on home prices found buyers were willing to pay immediate and sizable increases in home prices. They found that house prices rose by about six percent over the two to three years following bond passage and persisted for at least a decade. The researchers did not think these effects were a result of changes in the income or race of homeowners.<sup>xxiii</sup>

*"A 2004 survey of school principals by the National Center for Education Statistics found significant disparity in educational spaces available in schools with the highest poverty concentration compared to schools with the lowest poverty concentration."*

## INEQUITY IN SCHOOL FACILITY QUALITY

In the United States, public education has deep roots in systems of local control. Nowhere is this stronger than in regard to public school facilities.<sup>xxiv</sup> The federal government has virtually no role in funding or regulating public school facilities. States have widely varying levels of funding, regulation and technical assistance for local district facility responsibilities. One result of this structure of local responsibility and control is that the quality of school facilities varies by the income of the communities responsible for supporting the public schools.

Inequity of conditions in our public school facilities has been a long-standing problem. The 1995 GAO report found that, "...on every measure...the same subgroups consistently emerged as those with the most problems. These subgroups included central cities, the western region of the country, large schools, secondary schools, schools reporting student populations of at least 50.5 percent minority students and schools reporting student populations of 70 percent or more poor students."<sup>xxv</sup> The survey found that "...9.7 million or 67 percent of students in central cities attended schools reporting at least one inadequate building feature, such as plumbing."<sup>xxvi</sup>

A 2004 survey of school principals by the National Center for Education Statistics found significant disparity in educational spaces available in schools with the highest poverty concentration compared to schools with the lowest poverty concentration. High poverty schools had science labs 37 percent of the time, whereas low poverty schools had them 51 percent of the time. High poverty schools had art rooms 50 percent of the time compared to 80 percent of the time for low poverty schools. Disparities of about 20 percent were also found between high poverty schools and low poverty schools in the existence of music rooms and gymnasiums.<sup>xxvii</sup>

A 2006 analysis of public school construction from 1995-2004 found that, while there certainly were low-income communities that benefited from the \$304 billion of public school facility improvements during that decade, there was tremendous disparity overall between the capital investment in schools located in the low-income zip codes and those in the more affluent zip codes. Poor communities had far less spent on their school facilities than wealthier communities.<sup>xxviii</sup> This inequitable pattern of spending from 1995-2004 could only have exacerbated the disparities found in the 1995 GAO survey.

## CONCLUSION

The relevance of the quality of school facilities is obvious to students, parents and teachers. More and more studies are finding strong relationships between school facility quality and academic outcomes.<sup>xxix</sup> As public understanding of the impact of facilities on safety, health, education and communities has been growing, local and state governments have been working to build capacity to address the ongoing challenges of managing and modernizing this extensive public infrastructure.

Over the nearly 20 years since the GAO issued its report on the condition of the nation's school facilities, there has been some effort to define an appropriate federal role related to this critical infrastructure. Many federal agencies have programs that affect school facilities. The Environmental Protection Agency, U.S. Department of Education, U.S. Department of Energy, Federal Emergency Management Assistance Agency, Department of Defense Education Agency, Bureau of Indian Affairs, U.S. Department of Agriculture and U.S. Treasury all have programs geared toward

*"Lack of sufficient, comparable (state-to-state and year-to-year) facility data aligned to basic education data is hindering our ability to address the safety, health, education and environmental challenges of our public school facilities."*

helping improve our nation's public school facilities. However, these programs are extremely limited, and tend to be *ad hoc* and isolated. The importance of facility location, design, condition and utilization are not yet integrated into key elements of federal, state and local education initiatives or policy. For example, the signature U.S. Department of Education \$4.35 billion Race to the Top program includes no consideration of the health, safety or educational adequacy of school facilities when evaluating proposals to turn around low-performing schools, even though we know there is a high correlation among low-performing schools, or schools in low-income communities and poor quality school facilities.

*"The obstacle to a more complete understanding of facility needs is fear: fear that we will be called on to solve the problems but will not have the will or capacity to do so."*

Lack of sufficient, comparable (state-to-state and year-to-year) facility data aligned to basic education data is hindering our ability to address the safety, health, educational and environmental challenges of our public school facilities. At the federal, state, school district and individual school levels, the public needs to understand both the current extent of problems in our facilities and the educational opportunities that high quality public school facilities provide. We need to know the distribution of facility needs and the risks associated with deferred maintenance, crowded schools and insufficient capital investment. With more knowledge and better understanding, we can invest our limited resources more efficiently, effectively and equitably.

The obstacle to a more complete understanding of facility needs is fear: fear that we will be called on to solve the problems, but will not have the will or capacity to do so. Public officials and communities are afraid they will not find the money, time or experience to solve the problems of facilities in poor condition. However, just as inadequately accounting for sub-prime housing debt did not eliminate the underlying roots of impending collapse, deferred school building maintenance will not go away if local districts, states and the nation as a whole do not assess it.

The following recommendations are intended to help communities, states and the nation to get started down a road toward understanding where our school facilities stand. We need to trust that we will find the will and the way to meet these challenges. Our children and grandchildren deserve no less.

## RECOMMENDATIONS

Expand the Common Core of Data collected annually by the National Center for Education Statistics to include school level data on building age, building size and site size.

Improve the current fiscal reporting of school district facility maintenance and operations data to the National Center for Education Statistics so that utility expenditures and maintenance expenditures are collected separately.

Improve the collection of capital outlay data from school districts to include identification of the source of capital outlay funding and distinctions between capital outlay categories for new construction and for existing facilities.

Provide financial and technical assistance to states from the U.S. Department of Education to incorporate facility data in their state longitudinal education data systems.

**Mandate a GAO facility condition survey to take place every 10 years, with the next one beginning immediately.**

## ENDNOTES AND CITATIONS

i Numbers and Types of Public Elementary and Secondary Schools from the Common Core of Data: School Year 2010–11,” National Center for Education Statistics, accessed December 2012, [http://nces.ed.gov/pubs2012/pesschools10/tables/table\\_02.asp](http://nces.ed.gov/pubs2012/pesschools10/tables/table_02.asp)

ii U.S. Department of Education: National Center for Education Statistics, *Condition of America’s Public School Facilities: 1999*, NCES 2000-032 (Washington, D.C.: National Center for Education Statistics, 2000): vi, retrieved December 2012 from <http://nces.ed.gov/pubs2000/2000032.pdf>.

iii Mary Filardo, *Good Buildings, Better Schools: An economic stimulus opportunity with long-term benefits*, Economic Policy Institute Briefing Paper 216 (2008): 2, retrieved December 2012 from <http://www.21csf.org/csf-home/publications/GoodBuildingsBetterSchools-EPI-Paper.pdf>.

iv Replacement value was calculated by multiplying estimated square footage at elementary and secondary levels by the McGraw-Hill hard cost national average estimates for elementary and secondary new construction for 2008. McGraw-Hill estimates these costs at \$161 per square foot for elementary construction and \$154 per square foot for secondary school construction. Construction costs were down from \$200 per square foot and \$175 per square foot the previous year.

v Frank Johnson, Lei Zhou, and Nanae Nakamoto, *Revenues and Expenditures for Public Elementary and Secondary Education: School Year 2008–09 (Fiscal Year 2009)*, NCES 2011-329 (Washington, D.C.: National Center for Education Statistics, 2011): 6, retrieved December 2012 from <http://nces.ed.gov/pubsearch>.

vi Environmental Protection Agency, *Energy Efficiency Programs in K-12 Schools: A Guide to Developing and Implementing Greenhouse Gas Reduction Programs*, Local Government Climate and Energy Strategy Series (Washington, D.C.: Environmental Protection Agency, 2011): 1, retrieved December 2012 from [http://www.epa.gov/statelocalclimate/documents/pdf/k-12\\_guide.pdf](http://www.epa.gov/statelocalclimate/documents/pdf/k-12_guide.pdf).

vii Mary Filardo et al., *Growth and Disparity: A Decade of U.S. Public School Construction*, Building Educational Success Together (2006): 1, retrieved December 2012 from [http://www.edlawcenter.org/assets/files/pdfs/facilities/BEST\\_NationalReport\\_2008.pdf](http://www.edlawcenter.org/assets/files/pdfs/facilities/BEST_NationalReport_2008.pdf).

viii Filardo et al., *Growth and Disparity*, 9.

ix Government Accountability Office (formerly General Accounting Office): Health, Education and Human Services Division, *School Facilities: Condition of America’s Schools*, GAO/HEHS-95-61 (Washington, D.C.: Government Printing Office, 1995): 2, retrieved December 2012 from <http://www.gao.gov/archive/1995/he95061.pdf>.

x 21st Century School Fund, *Repair for Success: An Analysis of the Need and Possibilities for a Federal Investment in PK-12 School Maintenance and Repair*, (Washington, D.C.: 21st Century School Fund, 2009): 1, retrieved December 2012 from <http://www.21csf.org/csf-home/Documents/RepairforSuccessAugust2011.pdf>.

xi 21st Century School Fund, *Repair for Success*, 2

xii Revathy Kumar, Patrick O’Malley, and Lloyd Johnston, “Association between physical environment of secondary schools and student problem behavior: A national study, 2000-2003,” *Environment and Behavior* 40, no. 4 (2008): 455-486, retrieved December 2012 from DOI: 10.1177/0013916506293987. (Results based on multilevel logistic and linear regressions indicate that students are sensitive to schools’ ambience and that the association of various aspects of the school’s physical environment with students’ problem behaviors is positive for all students, and greater for 10th-grade students than for 8th- and 12th-grade students.)

xiii Stephen Plank, Catherine Bradshaw, and Hollie Young, “An Application of ‘Broken-Windows’ and Related Theories to the Study of Disorder, Fear, and Collective Efficacy in Schools,” *American Journal of Education* 115s, no. 2 (2009): 227-247, retrieved December 2012 from <http://www.journals.uchicago.edu/doi/abs/10.1086/595669>. (Path analyses reveal a direct association between physical disorder and social disorder even when prior levels of collective efficacy are controlled. Further, there is evidence that the effects of physical disorder may be operating through increased fear and decreased collective efficacy to affect perceptions of threat/violence.)

xiv Harvey Bernstein and Lindsay Baker, *The Impact of School Buildings on Student Health and Performance*, (Washington, D.C.: Center for Green Schools at USGBC, 2012): 6-17, retrieved December 2012 from <http://centerforgreenschools.org/studies/k12.aspx>

xv Indoor Air Quality: Scientific Findings Resource Bank, *The Impact of School Buildings on Student Health and Performance*, (Washington, D.C.: Center for Green Schools at USGBC, 2012): 6-17, retrieved December 2012 from <http://eetd.lbl.gov/ied/sfrb/>

## ENDNOTES AND CITATIONS (CONT'D)

<sup>xvi</sup> Bradley H. Turk et al., “Commercial building ventilation rates and particle concentrations,” *ASHRAE Transactions* 95 (1989) 422-433

<sup>xvii</sup> Jack Buckley, Mark Schneider, and Yi Shang, “Fix It and They Might Stay: School Facility Quality and Teacher Retention in Washington, D.C.,” *Teachers College Record* 107, no. 5 (2005): 1107-1123. December 2012

<sup>xviii</sup> School Facilities Improve Learning,” California Department of Education: School Facilities Services Division, accessed December 2012 6-17, retrieved December 2012, <http://www.cde.ca.gov/ls/fa/re/documents/learnercenter.pdf>.

<sup>xix</sup> 21st Century School Fund, *Research on the Impact of School Facilities on Students and Teachers: A Summary of Studies Published Since 2000*, (Washington, D.C.: 21st Century School Fund, 2010), retrieved December 2012 from <http://www.21csf.org/csf-home/Documents/ResearchImpactSchoolFacilitiesFeb2010.pdf>.

<sup>xx</sup> Buckley, Schneider, and Shang, *Fix It and They Might Stay*”

<sup>xxi</sup> Lorraine Maxwell and Gary Evans, “Chronic Noise Exposure and Reading Deficits: The Mediating Effects of Language Acquisition,” *Environment and Behavior* 29, (Washington, D.C.: 21st Century School Fund, 2010), no. 5 (1997): 638-656.

<sup>xxii</sup> “School Siting Guidelines,” Environmental Protection Agency, accessed January 2013, <http://www.epa.gov/schools/siting/download.html>.

<sup>xxiii</sup> Stephanie Riegg Cellini, Fernando Ferreira and Jesse Rothstein, “The Value of School Facility Investments: Evidence from a Dynamic Regression Discontinuity Design,” *The Quarterly Journal of Economics* 125, no. 1 (2010): 215-261.

<sup>xxiv</sup> Mary Filardo and Sean O’Donnell, *Federal Spending on PK-12 School Facilities*, 21st Century School Fund (2010), retrieved December 2012 from [http://www.ncef.org/pubs/federal\\_spending\\_on\\_school\\_facilities.pdf](http://www.ncef.org/pubs/federal_spending_on_school_facilities.pdf).

<sup>xxv</sup> Government Accountability Office (formerly General Accounting Office): Health, Education and Human Services Division, *School Facilities: America’s Schools Report Differing Conditions*, GAO/HEHS-96-103 (Washington, D.C.: Government Printing Office, 1996): 2, retrieved December 2012 from <http://www.gao.gov/archive/1995/he95061.pdf>

<sup>xxvi</sup> GAO: Health, Education and Human Services Division, *School Facilities: School Facilities: America’s Schools Report Differing Conditions*, 17.

<sup>xxvii</sup> U.S. Department of Education: National Center for Education Statistics, *Public School Principals’ Perceptions of Their School Facilities: Fall 2005*, NCES 2008-011 (Washington, D.C.: National Center for Education Statistics, 2008), retrieved December 2012 from <http://nces.ed.gov/surveys/frss/downloads.asp#FRSS13>.

<sup>xxviii</sup> Filardo et al., *Growth and Disparity*, 17

<sup>xxix</sup> 21st Century School Fund: National Center for Education Statistics, *Research on the Impact of School Facilities on Students and Teachers: A Summary of Studies Published Since 2000*.

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## **Green K-12 Schools and the LEED® for Schools Green Building Rating System™**

Green schools are designed to be healthy for both occupants and the environment while saving water and energy. By promoting the design & construction of green schools, we can make a tremendous impact on student health, school operational costs, test scores and the environment.

The green school itself also serves as a teaching tool – demonstrating to students, faculty, and parents practical ways that we can turn back the clock on global warming while creating healthier, more efficient learning environments.

### **Environmental Benefits**

- LEED certified green buildings use 30-50% less energy and 40% less water, and reduce harmful Carbon Dioxide emissions by 38%.

### **Student and Teacher Benefits**

- Improved student health, test scores, faculty retention.
- Green schools have better lighting, temperature control, improved ventilation and indoor air-quality which contribute to reduced asthma, colds, flu and absenteeism. Green schools reduce the dangerous air-pollutants that cause respiratory diseases.

### **Financial Benefits**

- Building green offers dramatic reductions in operations and maintenance costs.
- Green schools can save \$100,000 per year—enough to hire two new teachers, buy 150 new computers, or purchase 5000 new textbooks.

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LEED for Schools is a green building rating system developed by the U.S. Green Building Council for K-12 schools and higher education buildings. The rating system is designed to improve children’s health, productivity and learning capacity while also helping school building to be more energy efficient and resource friendly.

LEED is like a “nutritional label” for green, healthy schools so you know exactly where your children are spending their days.

The LEED for Schools Rating System emphasizes:

- classroom acoustics
- master planning
- indoor air quality
- mold prevention
- energy efficiency
- water conservation



# Greening America's Schools

## COSTS AND BENEFITS

Gregory Kats

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American Federation of Teachers  
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American Lung Association  
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Greg Kats is Managing Principal of Capital E, a national clean energy technology and green building firm. He serves as Senior Advisor to Cherokee Investment Partners ([www.cherokeefund.com](http://www.cherokeefund.com)), the country's largest private brownfield developer (*with over \$5 billion in projected green developments*). He is the Principal Advisor in developing \$1 billion of green affordable housing, involving Enterprise Community Partners, JPMorgan, Chase, Citibank, NRDC, Fannie Mae, American Institute of Architects, and others ([www.greencommunitiesonline.org](http://www.greencommunitiesonline.org)). He serves as Senior Advisor to the Cheyenne Carbon Fund, the leading investor in the voluntary carbon offset market. (*Cheyenne Capital Management is a \$30 billion European hedge fund.*)

Mr. Kats served as the Director of Financing for Energy Efficiency and Renewable Energy at the U.S. Department of Energy (1996-2001). With a billion dollar budget, it is the country's largest clean technology development and deployment program, including over \$400 million annually in high performance building technology development and deployment. He co-founded and from 1995 to 2001 chaired the International Performance Measurement & Verification Protocol ([www.ipmvp.org](http://www.ipmvp.org)) that has served as a technical basis for \$8 billion in building upgrades, and been translated into 10 languages. Mr. Kats serves as Chair of the Energy and Atmosphere Technical Advisory Group for LEED and serves on the LEED Steering Committee. Mr. Kats recently led a national technical review (*for the US EPA*) on the performance of Energy Star commercial and public buildings, and is a principal author of *Green Office Buildings: a Practical Guide to Development*, (*Urban Land Institute, 2005*).

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This document is based on and draws from the 2005 report "National Review of Green Schools: Costs, Benefits and Implications for Massachusetts," a report for the Massachusetts Technology Collaborative. principal author Greg Kats, contributing author Jeff Perlman, contributing researcher Sachin Jamadagni. (*Available at [www.cap-e.com](http://www.cap-e.com).*)

This analysis also draws extensively on the 2003 Capital E report "The Costs and Financial Benefits of Green Buildings", a report to California's Sustainable Building Task Force, developed for 40 state agencies.<sup>1</sup> The report was the first to develop a rigorous analysis of the costs and benefits of green buildings, and found that the average cost premium for green buildings was 2%.

# Greening America's Schools

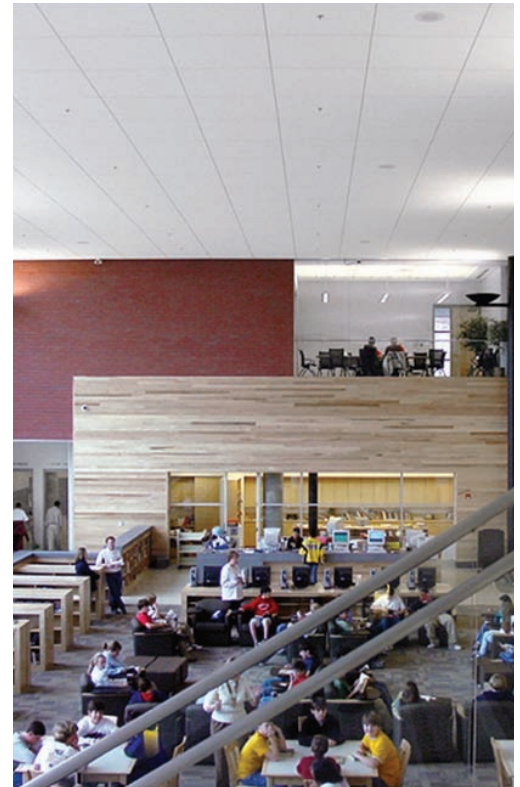
## COSTS AND BENEFITS

**“This carefully documented study conclusively demonstrates the financial, environmental, and other benefits of using green technologies in schools.** In fact, failure to invest in green technologies is not financially responsible for school systems; the study uses conservative accounting practices to show that investments in green technologies significantly reduce the life-cycle cost of operating school buildings. And the public benefits of green schools are even larger than those that work directly to the financial advantage of schools. These include reductions in water pollution, improved environmental quality, and increased productivity of learning in an improved school environment.”

— Henry Kelly, President, Federation of American Scientists

“This important study persuasively demonstrates that it costs little more to build high performance, healthy schools and that there are enormous financial, educational and social benefits to students, schools and society at large.”

— Edward J. McElroy, President, American Federation of Teachers, AFL-CIO



## EXECUTIVE SUMMARY

Some 55 million students spend their days in schools that are too often unhealthy and that restrict their ability to learn. A recent and rapidly growing trend is to design schools with the specific intent of providing healthy, comfortable and productive learning environments. These green, high performance schools generally cost more to build, which has been considered a major obstacle at a time of limited school budgets and an expanding student population. A 2005 survey by Turner Construction Company of 665 senior executives found that executives are discouraged from undertaking green construction because of concerns about cost, and a lack of awareness and available information on the financial benefits of green buildings.<sup>2</sup>

**This report is intended to answer this fundamental question: how much more do green schools cost, and is greening schools cost effective?**

Conventional schools are typically designed just to meet building codes — that are often incomplete. Design of schools to meet minimum code performance tends to minimize initial capital costs but delivers schools that are not designed specifically to provide comfortable, productive, and healthy work environments for students and faculty. Few states regulate indoor air quality in schools or provide for minimum ventilation standards. **Not surprisingly, a large number of studies have found that schools across the country are unhealthy — increasing illness and absenteeism and bringing down test scores.**

This report documents the financial costs and benefits of green schools compared to conventional schools. This national review of 30 green schools demonstrates that green schools cost less than 2% more than conventional schools - or about \$3 per square foot (\$3/ft<sup>2</sup>) - but provide financial benefits that are 20 times as large. Greening school design provides an extraordinarily cost-effective way to enhance student learning, reduce health and operational costs and, ultimately, increase school quality and competitiveness.

The financial savings are about \$70 per ft<sup>2</sup>, 20 times as high as the cost of going green. (Table A) Only a portion of these savings accrue directly to the school. Lower energy and water costs, improved teacher retention, and lowered health costs save green schools directly about \$12/ft<sup>2</sup>, about four times the additional cost of going green. For an average conventional school, building green would save enough money to pay for an additional full-time teacher. Financial savings to the broader community are significantly larger, and include reduced cost of public infrastructure, lower air and water pollution, and a better educated and compensated workforce.

Green schools provide a range of additional benefits that are not quantified in this report, including reduced teacher sick days, reduced operations and maintenance costs, reduced insured and uninsured risks, improved power quality and reliability, increased state competitiveness, reduced social inequity, and educational enrichment. There is insufficient data to quantify these additional benefits, but they are substantial and, if calculated, would substantially increase the recognized financial benefits of greening schools.

Building healthy high performance school buildings is now far more fiscally prudent and lower risk than building conventional, inefficient and unhealthy school buildings.

## METHODOLOGY AND ASSUMPTIONS

### NET PRESENT VALUE

Conventional schools usually have lower design and construction costs and higher operational costs, whereas green schools usually have higher design and construction costs and lower operational costs. To evaluate the current value of a future stream of

**Greening school design provides an extraordinarily cost-effective way to enhance student learning.**

TABLE A

Financial Benefits of Green Schools (\$/ft <sup>2</sup> )	
Energy	\$9
Emissions	\$1
Water and Wastewater	\$1
Increased Earnings	\$49
Asthma Reduction	\$3
Cold and Flu Reduction	\$5
Teacher Retention	\$4
Employment Impact	\$2
<b>Total</b>	<b>\$74</b>
<b>Cost of Greening</b>	<b>(\$3)</b>
<b>Net Financial Benefits</b>	<b>\$71</b>

financial benefits and costs, we use net present value (NPV) analysis, with 2006 as our base year. NPV represents the present value of an investment's discounted future financial benefits minus any initial investment. A positive number indicates a good investment.

#### TERM

This report assumes a 20 year term for benefits in new buildings. A lower, 15 year term for energy efficiency savings in retrofitted existing buildings would be appropriate. A longer term is assumed for a new building because green design affects more permanent features — such as orientation, wall construction, and amount of insulation — which tend to last for the life of building, typically at least 50 years.

#### INFLATION

This analysis assumes an inflation rate of 2% per year, in line with most conventional inflation projections. Unless otherwise indicated, this report makes a conventional assumption that most costs as well as benefits rise at the rate of inflation. The things that are not assumed to rise at the rate of inflation are energy, emissions value, water, waste water and health costs — which are assumed to rise faster than inflation. The rate increases for these are discussed in the relevant sections.

#### DISCOUNT RATE

To arrive at present value and net present value estimates, projected future costs and benefits must be discounted to provide a fair value in today's dollars. Present value calculations are made on the basis of a relatively conservative 7% discount rate (i.e., 5% real interest rate plus an assumed 2% inflation).<sup>3</sup> This is higher than the rate at which states, the federal government, and many corporations borrow money.<sup>4</sup>

#### DEFINITION OF GREEN SCHOOLS

All green school designs are to a substantial extent based on the US Green Building Council's Leadership in Energy and Environmental Design (LEED), which is the national consensus green building standard. An application of LEED for schools was developed for California schools, and is called Collaborative for High Performance Schools (CHPS).<sup>5</sup> This standard was then adapted for Massachusetts schools (MA CHPS),<sup>6</sup> and in 2003, Washington State released its own Washington Sustainable School (WSS) Protocol for High Performance Facilities,<sup>7</sup> also based on a variant of CHPS and LEED. The green schools we analyzed were based on either LEED, MA CHPS, or WSS.

## THE COST OF BUILDING GREEN SCHOOLS

Average national school construction cost is \$150/ft<sup>2</sup>.<sup>8</sup>

The "green premium" is the initial extra cost to build a green building compared to a conventional building. Typically this cost premium is a result of more expensive (and sustainably-sourced) materials, more efficient mechanical systems, and better design, modeling and integration, and other high performance features. Many school architects use a state or school district's pre-determined budget as their metric for appropriate school cost. Some green schools are built on the same budget as conventional schools.

The report data are drawn from 30 green schools built in 10 states during the period 2001 to 2006. The data on costs as well as savings compared to a conventional design were generally supplied by the schools' architects. Some of the costs analyzed in the report are based on actual building performance, while some new school costs are estimates based on architectural modeling and engineering estimates. We generally relied on the costs reported by architects based on their actual and modeled green and conventional versions of the same building. For a breakout of all schools analyzed, see *Table B*.

### FIGURE A Factors Discouraging the Construction of Green Buildings

Percent of executives rating factor as very or extremely significant in discouraging green construction



Higher Construction Costs



Lack of Awareness of Benefits



Difficulty Quantifying Benefits

SOURCE:  
Turner Construction Company 2005 Survey of Green Buildings

## Some green schools are built on the same budget as conventional schools.

Four of the green schools (in Georgia, Massachusetts and Oregon) cost no more than conventional design, while several schools cost substantially more. Six schools cost at least 3% more than conventional design while one – the Punahou School in Hawaii – costs 6.3% more. Typically green schools cost 1% to 2% more, with an average cost premium of 1.7%, or about \$3/ft<sup>2</sup>.

Increased cost of green design is typically partially offset by savings elsewhere, for example in reduced cost of HVAC systems or in reduced code compliance costs. Similarly, increased water retention through the use of a green roof or greywater system can avoid the capital cost of a water retention system normally required to comply with water codes. The model green school developed by the architectural firm OWP/P for the Chicago market includes a green roof that allows the building to avoid a water retention system, providing savings sufficient to reduce the school cost premium to 1%.<sup>10</sup> A recent evaluation of the impact of LEED adoption, developed for the Portland Energy Office, found that regional life cycle savings from adopting 15 individual green building technologies was over 8 times as large as the direct first cost of these measures.<sup>11</sup>

Achieving full cost savings requires early integrated design.

## BENEFITS OF HIGH PERFORMANCE SCHOOLS

### Energy Cost Savings in Green Schools

Green schools use an average of 33% less energy than conventionally designed schools (See Table B). Typical energy performance enhancements include more efficient lighting, greater use of daylighting and sensors, more efficient heating and cooling systems and better insulated walls and roofs.

Reduced energy consumption in green schools has two distinct financial benefits: (1) direct reduction in school energy costs, and (2) indirect secondary impact from reduced overall market demand and resulting lower energy prices market-wide. Direct savings are in the form of lower bills to the school. Indirect savings result from the impact that reduced demand has in lowering the market price of energy. This indirect impact shows up in minute changes in price across entire markets. For an individual school, this price impact is not measurable, but state-wide or nationally, the price impact of reduced energy consumption in schools could be substantial.

Average school energy use in 2005/2006 was \$1.15/ft<sup>2</sup>, of which electricity was 63% and natural gas 34%. For the 30 green schools reviewed in this report, the average energy reduction compared with conventional design is 33%, indicating an average savings of \$0.38/ft<sup>2</sup> per year in green schools.<sup>12</sup> Average electricity prices are \$0.09 kWh in 2006 and rose an average 6% per year over the last three years.<sup>13</sup> The average gas price rose 14% annually over the same period. Future prices are of course unknowable, but finite energy resources combined with rapid projected international demand growth suggests rising prices. This report projects recent rapid growth in average energy prices to slow to 5% per year, or 3% above inflation, over the next 20 years.

Over a 20 year period, and assuming 7% discount of future benefits of lower energy prices, the result is a present value of \$6/ft<sup>2</sup> for energy savings in green schools. In green building upgrades of existing schools, the present value benefit of reduced energy use over a 15 year period at a 7% discount rate is \$5/ft<sup>2</sup>. Note that the costs and benefits numbers in this report have all been rounded to the nearest whole dollar amount. Uncertainties about the data, including future price escalation, make greater precision misleading.



**Homewood Middle School**  
Giattina Fisher Aycock Architects  
Photo: John O'Hagan

TABLE B: SCHOOL BUILDINGS ANALYZED IN THIS REPORT<sup>9</sup>

Name	State	Year Completed	2005 MA-CHPS	LEED Score	LEED Level or Equivalent	Cost premium	Energy Savings	Water Savings
Ash Creek Intermediate School	OR	2002			CERTIFIED	0.00%	30%	20%
Ashland High School*	MA	2005	19			1.91%	29%	
Berkshire Hills*	MA	2004	27			3.99%	34%	0%
Blackstone Valley Tech*	MA	2005	27			0.91%	32%	12%
Capuano	MA	2003		26	CERTIFIED	3.60%	41%	
Canby Middle School	OR	2006		40	GOLD	0.00%	47%	30%
Clackamas	OR	2002		33	SILVER	0.30%	38%	20%
Clearview Elementary	PA	2002	49	42	GOLD	1.30%	59%	39%
Crocker Farm School	MA	2001	37			1.07%	32%	62%
C-TEC	OH	2006	35	38	SILVER	0.53%	23%	45%
The Dalles Middle School	OR	2002			SILVER	0.50%	50%	20%
Danvers*	MA	2005	25			3.79%	23%	7%
Dedham*	MA	2006	32			2.89%	29%	78%
Lincoln Heights Elementary School	WA	2006			SILVER		30%	20%
Melrose Middle School	MA	2007	36			1.36%	20%	20%
Model Green School	IL	2004		34	SILVER	2.02%	29%	35%
Newton South High School	MA	2006		32	CERTIFIED	0.99%	30%	20%
Prairie Crossing Charter School	IL	2004		34	SILVER	3.00%	48%	16%
Punahou School	HI	2004		43	GOLD	6.27%	43%	50%
Third Creek Elementary	NC	2002		39	GOLD	1.52%	26%	63%
Twin Valley Elementary	PA	2004	41	35	SILVER	1.50%	49%	42%
Summerfield Elementary School	NJ	2006	42	44	GOLD	0.78%	32%	35%
Washington Middle School	WA	2006		40	GOLD	3.03%	25%	40%
Whitman-Hanson*	MA	2005	35			1.50%	35%	38%
Williamstown Elementary School	MA	2002	37			0.00%	31%	
Willow School Phase 1	NJ	2003		39	GOLD		25%	34%
Woburn High School*	MA	2006	32			3.07%	30%	50%
Woodward Academy Classroom	GA	2002		34	SILVER	0.00%	31%	23%
Woodward Academy Dining	GA	2003		27	CERTIFIED	0.10%	23%	25%
Wrightsville Elementary School	PA	2003		38	SILVER	0.40%	30%	23%
<b>AVERAGE</b>						<b>1.65%</b>	<b>33.4%</b>	<b>32.1%</b>

**Market-wide energy cost savings represent an important benefit often not included in energy efficiency financial analyses.**

Market-wide energy cost savings represent an important additional benefit often not included in energy efficiency financial analyses. The financial benefit of lowered energy prices is substantial and provides an additional reason for public entities such as states or cities to promote or require energy efficiency programs.

The price impact from efficiency-driven reductions in demand can be significant. A 2005 report from Lawrence Berkeley National Laboratory found that a 1% reduction in national natural gas demand can lead to a long-term average wellhead price reductions of 0.8% to 2%.<sup>14</sup> A 2004 Platts Research & Consulting review of nine separate studies determines that a 1% drop in gas demand could drive a 0.75% to 2.5% reduction in long-term wellhead prices.<sup>15</sup> In other words, these studies indicate direct reduction in consumption (and savings in energy costs from increased efficiency) could drive a reduction in long-term prices equal to 100% to 200% of the direct energy savings. A 2004 Massachusetts state report found that the indirect savings from lower overall energy prices due to lower energy demand from use of energy efficiency and renewables amounted to 90% of the direct savings.<sup>16</sup> To be conservative, we assume that the indirect price impact is 50% over 20 years from a broad shift to green, energy efficient school design. Thus, the impact of indirect energy cost reduction for new and retrofitted schools has a present value of \$3/ft<sup>2</sup> over 20 years.

The total direct and indirect energy cost savings from a new green school compared with a conventional school is \$9/ft<sup>2</sup>. Total direct and indirect energy cost savings from a green as compared to a conventional upgrade of an existing school would be \$7/ft<sup>2</sup>. Note that these numbers have all been rounded to the nearest whole dollar amount, as noted above.

**Emissions Reduction Benefits of Green Schools**

Residential, commercial and industrial buildings use about 45% of the nation’s energy, including about 75% of the nation’s electricity. Air pollution, from burning fossil fuels to heat buildings (natural gas and oil) and to generate electricity for these buildings (by burning coal, natural gas and oil) imposes enormous health, environmental, and property damage costs. Demonstrated health costs nationally include tens of thousands of additional deaths per year and tens of millions of respiratory incidents and ailments.<sup>17</sup>

Reduced electricity and gas use in buildings means lower emissions of pollutants (due to avoided burning of fossil fuels) that are damaging to human health, to the environment, and to property. As noted above, green schools on average use one third less energy than conventional schools.<sup>18</sup>

As a rough estimate, a green school could lead to the following annual emission reductions per school:

- 1,200 pounds of nitrogen oxides (NOx) – a principal component of smog.
- 1,300 pounds of sulfur dioxide (SO<sub>2</sub>) – a principal cause of acid rain.
- 585,000 pounds of carbon dioxide (CO<sub>2</sub>) – the principal greenhouse gas and the principal product of combustion.
- 150 pounds of coarse particulate matter (PM10) – a principal cause of respiratory illness and an important contributor to smog.

Over 20 years the present value of emissions reductions per square foot is \$0.53/ft<sup>2</sup> from a green school.<sup>19</sup>

This grossly underestimates actual emissions costs, particularly for CO<sub>2</sub>, the primary gas causing global warming and resulting in increased severity of hurricanes, increased heat related deaths, sea-level rise, accelerating environmental degradation - such as erosion and desertification, and accelerating species extinction. A 2005 study by Harvard Medical School, Swiss Re and the United Nations Development Program summarizes a



**Clearview Elementary School**  
John Boecker, L. Robert Kimball & Assoc.  
Photo: Jim Schafer Location Photography



broad range of large economic costs that continued climate change and global warming, driven primarily by burning fossil fuels, will increasingly impose.<sup>20</sup>

Virtually all of the world's climate change scientists have concluded that human caused emissions - principally from burning fossil fuels — are causing global warming.<sup>21</sup> In 2004, *Science* published a review of over 900 scientific studies on global warming published in refereed scientific journals over the prior decade and concluded that there is a consensus among climate scientists that serious human induced global warming is happening.<sup>22</sup> In April 2005, James Hansen, Director of NASA's Goddard Institute for Space Studies, stated that "There can no longer be genuine doubt that human-made gases are the dominant cause of global warming."<sup>23</sup>

The USA is responsible for about one quarter of global greenhouse gas emissions. The building sector (including residential, commercial and industrial buildings) is responsible for over 40% of US CO<sub>2</sub> emissions — more than any other entire economy in the world except China.

The large health, environmental and property damages associated with pollution from burning fossil fuels are only very partially reflected in the price of emissions. As the health, financial and social costs of global warming in particular continue to mount, cutting greenhouse gasses through energy efficiency and greater use of renewable energy in buildings will become an increasingly valued benefit of greening buildings.<sup>24</sup>

### Water & Wastewater Benefits of Green Schools

The 30 green schools evaluated achieved an average water use reduction of 32%. This reduction has direct savings for the building as well as substantial societal benefits from lower pollution and reduced infrastructure costs to deliver water and to transport and treat wastewater.

When there is heavy and extended rainfall, wastewater systems commonly overflow, causing water pollution and illness, river contamination and beach closings. The benefits of some green building water strategies - such as rainwater catchment and green roofs - are recognized by some municipalities. For example, in Dedham, MA, the school design team, through providing rainwater storage capacity on site, saved the town the cost of enlarging an off site stormwater detention facility. The city valued this infrastructure improvement at \$400,000.<sup>25</sup>

A recent EPA report concludes that the expected gap between future revenues (based on historical price increases) and infrastructure needs for potable water and wastewater treatment will be approximately \$148 billion over the next twenty years.<sup>26</sup> EPA found that nationally there is a gross under-investment in water delivery and treatment systems, indicating that current water utility rates will have to rise more steeply to secure the funds needed for required infrastructure upgrades.

An empirical study in Canada estimated that the price charged for fresh water was only one-third to one-half the long-run marginal supply cost, and the prices charged for sewage were approximately one-fifth the long run cost of sewage treatment.<sup>27</sup>

Prices typically reflect average rather than marginal costs. Because water and wastewater costs are generally rising, prices tend to substantially understate actual marginal cost of additional water and wastewater capacity borne by utilities and society at large. Based on discussions with school and green building experts, we can assume conservatively that water and wastewater costs for schools average 5% of the cost of energy, or about \$0.06/ft<sup>2</sup>. Assuming an average rate of cost increase of 5% per year for water and wastewater, this provides an NPV estimate of \$0.84/ft<sup>2</sup>, or roughly one dollar, over 20 years. This almost certainly underestimates the financial benefits of reduced water and sewer cost associated with green design. Nor does it reflect the large savings from reduced water runoff from green schools and the cost savings from reduced water pollution and increased groundwater recharging.



**Mabel Rush High School**  
Heinz Rudolf, Boora Architects  
Photo: Michael Mathers

**The building sector is responsible for over 40% of US CO<sub>2</sub> emissions - more than any entire economy in the world except China.**

# NEW LEED PROGRAM FOR K-12 SCHOOLS

Lindsay Baker, USGBC staff

In December 2006, USGBC is launching LEED for Schools, a market-specific application of LEED that recognizes the unique nature and educational aspects of the design and construction of K-12 schools. The rating system is based on LEED for New Construction, and addresses issues such as classroom acoustics, master planning, mold prevention, and joint use of facilities. The program launch (no pilot period will take place) is supported by a full set of tools tailored to schools: a reference guide, workshop, and LEED Online with credit templates. In doing so, USGBC hopes to help school districts across the country better understand the business case for building green and to help them to implement their green building goals through a third-party certification program that is supported by educational offerings and a nationwide network of LEED Accredited Professionals, USGBC chapters and members. School districts can implement LEED without the additional cost of establishing in-house certification programs.

For more information on the LEED for Schools program, go to [www.usgbc.org/leed](http://www.usgbc.org/leed).

## Health and Learning Benefits of Green Schools

According to the US General Accounting Office, 14 million students (over a quarter of all students) attend schools considered below standard or dangerous and almost two-thirds of schools have building features such as air conditioning that are in need of extensive repair or replacement. This statistic does not include schools with less obvious but important health related problems such as inadequate ventilation. A recently published document by the American Federation of Teachers notes that the General Accounting Office found that the air is unfit to breathe in nearly 15 thousand schools.<sup>28</sup>

Poor health and study conditions in schools are of particular concern for a number of reasons, including:

- There are some 60 million students, faculty and staff in schools.
- The large majority of schools are built not to optimize health and comfort, but rather to achieve a minimum required level of design performance at lowest cost.
- Few states regulate indoor air quality in schools or provide for minimum ventilation standards.
- Almost no schools are designed with the specific objective of creating healthy and productive study and learning environments.
- Chronic shortage of funds in schools means that schools typically suffer from inadequate maintenance, and experience degradation of basic systems such as ventilation, air quality and lighting quality, as well as poor control over pollutants (e.g., from cleaning materials).
- Students and faculty typically spend 85% to 90% of their time indoors (mostly at home and at school), and the concentration of pollutants indoors is typically higher than outdoors, sometimes by as much as 10 or even 100 times.<sup>29</sup>
- Children are growing, their organs are developing, and they breathe more air relative to their body size than adults, and as a result sustain greater health problems and risks than adults from toxics and pollutants common in schools.<sup>30</sup>

The costs of poor indoor environmental and air quality in schools, including higher absenteeism and increased respiratory ailments, have generally been “hidden” in sick days, lower teacher and staff productivity, lower student motivation, slower learning, lower tests scores, increased medical costs, and lowered lifelong achievement and earnings.

There is a large body of research linking health and productivity with specific building design operation attributes (e.g., indoor air quality and control over work environment, including lighting levels, air flow, humidity, and temperature).

**There is a large body of research linking health and productivity with specific building design attributes.**

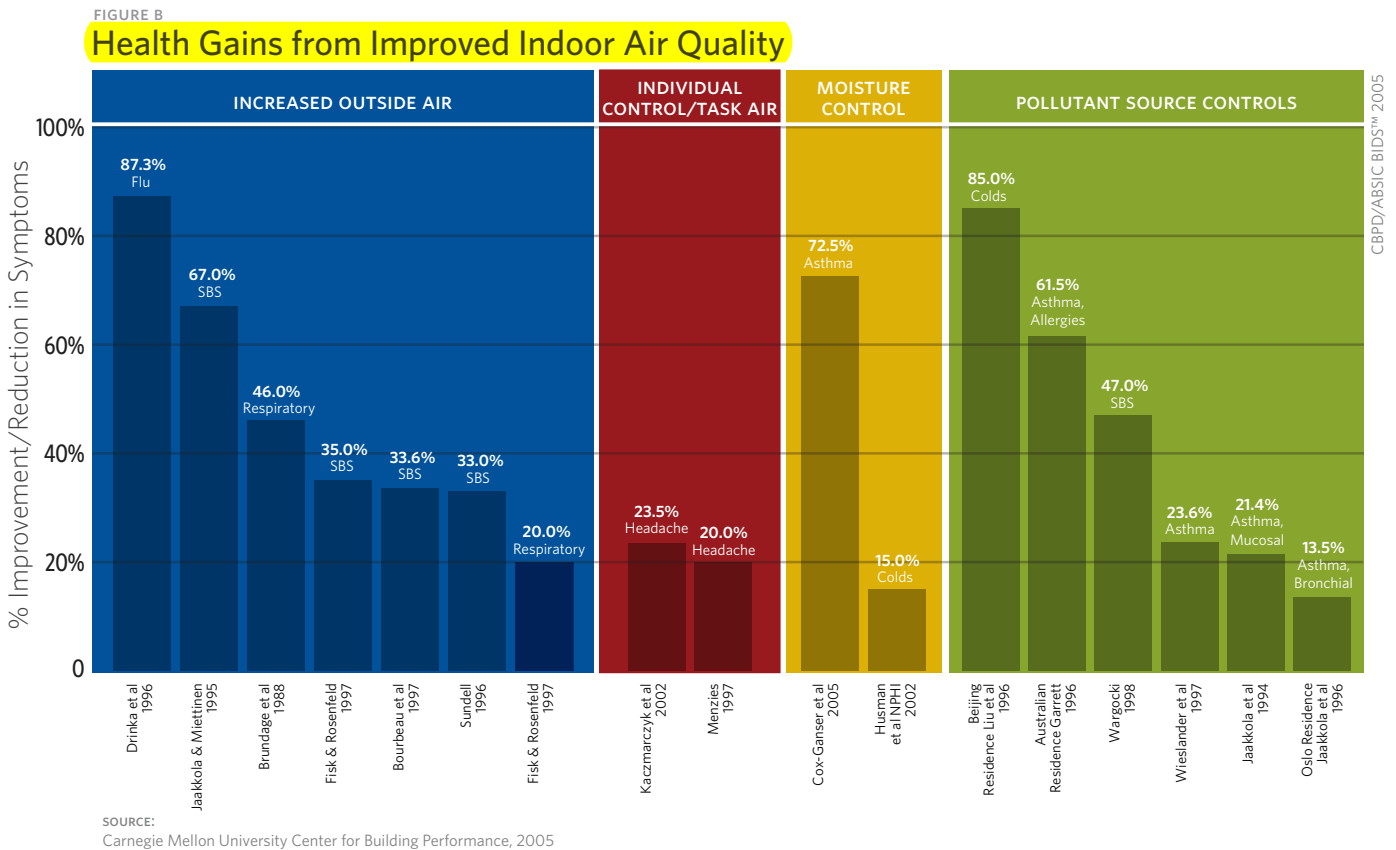
However, many reviews of the effects of classroom healthiness on students look only at school-specific studies. This unnecessarily limits the relevant data available to understand and quantify benefits of high performance, healthy design in schools. The tasks done by “knowledge workers” (including most non-factory white collar workers) – such as reading comprehension, synthesis of information, writing, calculations, and communications – are very similar to the work students do. Large-scale studies correlating green or high performance features with increased productivity and performance in many non-academic institutions are therefore relevant to schools.

Two studies of over 11,000 workers in 107 European buildings analyzed the health effect of worker-controlled temperature and ventilation. These studies found significantly reduced illness symptoms, reduced absenteeism and increased productivity relative to workers in a group whose workspace lacked these features.<sup>31</sup>

One of the leading national centers of expertise on the topic is the Center for Building Performance at Carnegie Mellon University. The Center’s Building Investment Decision Support (BIDS) program has reviewed over 1,500 studies that relate technical characteristics of buildings, such as lighting, ventilation and thermal control, to tenant responses, such as productivity or health.<sup>32</sup>

Collectively, these studies demonstrate that better building design correlates with increases in tenant/worker well-being and productivity. The BIDS data set includes a number of controlled laboratory studies where speed and accuracy at specific tasks, such as typing, addition, proof reading, paragraph completion, reading comprehension, and creative thinking, were found to improve in high performance building ventilation, thermal control, and lighting control environments.<sup>33</sup>

**17 separate studies all found positive health impacts from improved indoor air-quality, ranging from 13.5% up to 87% improvement.**



**Good lighting “improves test scores, reduces off-task behavior, and plays a significant role in the achievement of students.”**

**INDOOR AIR QUALITY**

The Carnegie Mellon building performance program identified 17 substantial studies that document the relationship between improved air quality and health. The health impacts include asthma, flu, sick building syndrome, respiratory problems, and headaches. These 17 separate studies all found positive health impacts (i.e. reduction in reported prevalence of symptoms) ranging from 13.5% up to 87% improvement, with average improvement of 41% (Figure B).

**TEMPERATURE CONTROL**

Teachers believe that temperature comfort affects both teaching quality and student achievement.<sup>34</sup> Research indicates that the best teachers emphasized that their ability to control temperature in classrooms is very important to student performance.<sup>35</sup>

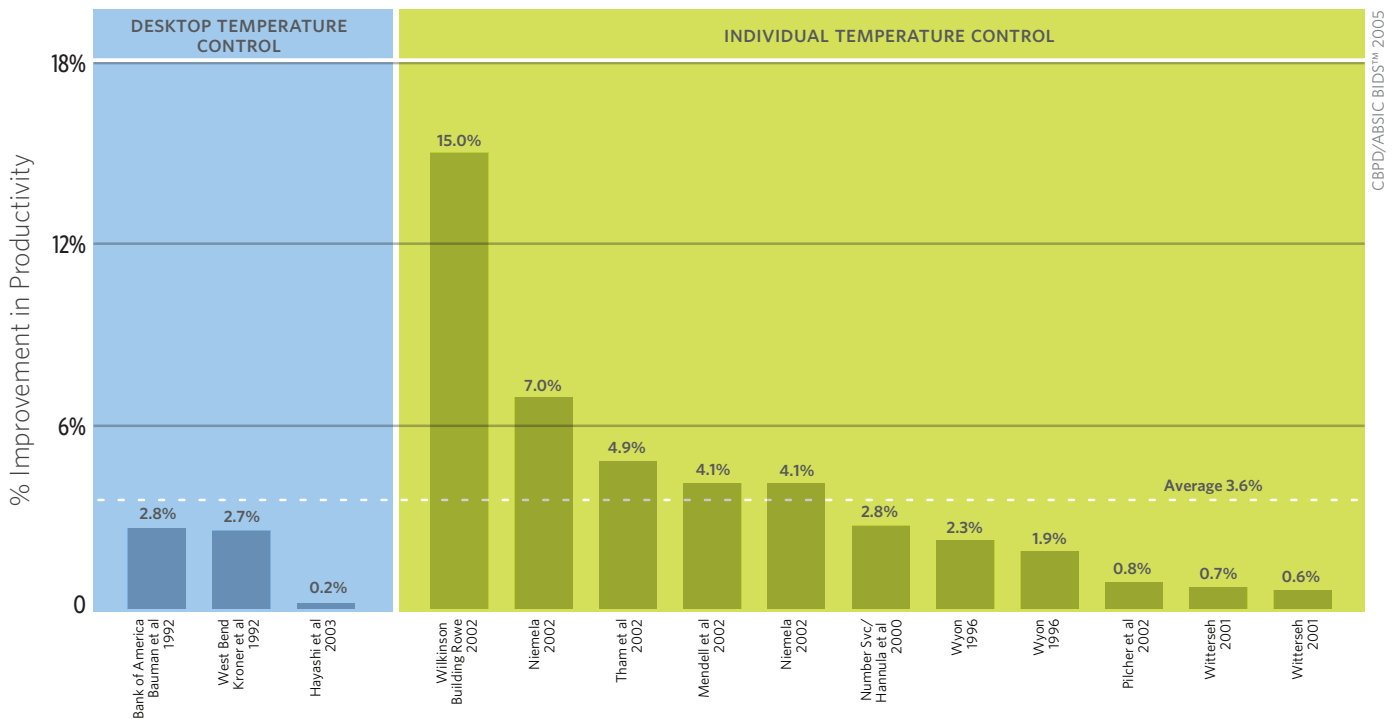
A review of 14 studies by Carnegie Mellon on the impact of improved temperature control on productivity found a positive correlation for all studies, with productivity improvements ranging from 0.2% up to 15%, and with an average (mean) of 3.6% (Figure C).

**HIGH PERFORMANCE LIGHTING**

Green school design typically emphasizes providing views and managing daylight – specifically increasing daylight while eliminating glare. These two design features have both been correlated with improvements in performance on tests of office workers. In a study of 200 utility workers, workers with the best views performed 10% -25% better on tests. Workers in offices without glare outperformed workers in offices with glare by 15% or more.<sup>36</sup> The consensus findings in a review of 17 studies from the mid 1930s to 1997 found that good lighting “improves test scores, reduces off-task behavior, and plays a significant role in the achievement of students.”<sup>37</sup> Another synthesis of 53 generally more recent studies also found that more daylighting fosters higher student achievement.<sup>38</sup>

FIGURE C

**Productivity Gains From Improved Temperature Controls**



SOURCE: Carnegie Mellon University Center for Building Performance, 2005

CBPD/ABSIC BIDS™ 2005

Carnegie Mellon summarized findings from 11 studies documenting the impact of high performance lighting fixtures on productivity. Their analysis found that productivity gains ranged between 0.7% and 26.1% with an average (median) of 3.2%. (Figure D).

The high performance lighting attributes include efficient lighting and use of indirect lighting fixtures, features that are normal in high performance green buildings.

### IMPROVED LEARNING AND TEST SCORES

In fall 2005 Turner Construction released a survey of 665 executives at organizations involved in the building sector. Of those involved with green schools, over 70% reported that green schools reduced student absenteeism and improved student performance.<sup>39</sup> (Figure E).

A large number of school specific studies indicate a significant positive impact. For example:

- An analysis of two school districts in Illinois found that student attendance rose by 5% after incorporating cost-effective indoor air quality improvements.<sup>40</sup>
- A study of Chicago and Washington, DC schools found that better school facilities can add 3 to 4 percentage points to a school's standardized test scores, even after controlling for demographic factors.<sup>41</sup>
- A recent study of the cost and benefits of green schools for Washington State estimated a 15% reduction in absenteeism and a 5% increase in student test scores.<sup>42</sup>

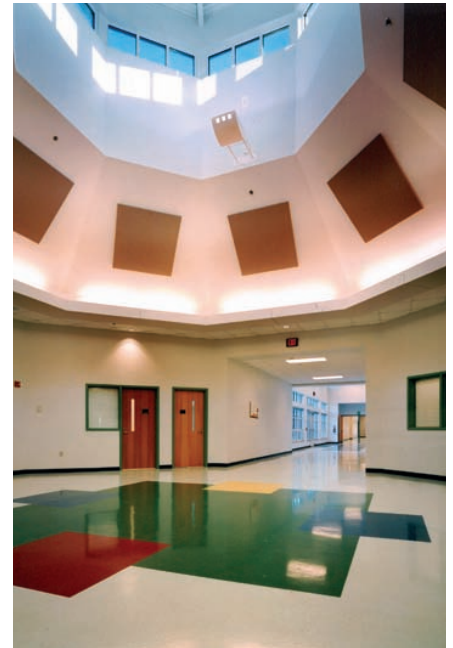
Three of the green schools analyzed for this report demonstrate similar significant improvements in performance:

- Students moving into the Ash Creek Intermediate School in Oregon (See Table B) experienced a 15% reduction in absenteeism.<sup>43</sup>
- Students moving from a conventional school to the new green Clearview Elementary School, a 2002 LEED Gold building in Pennsylvania (See Table B and photo on page 14), experienced substantial improvements in health and test scores. A PhD thesis on the school found a 19% increase in average Student Oral Reading Fluency Scores (DIBELS) when compared to the prior, conventional school.<sup>44</sup>
- The Third Creek Elementary School in Statesville, North Carolina (See Table B and front cover photo) is the country's first LEED gold K-12 school. Completed in 2002, the 800 student school replaced two older schools. Documented student test scores before and after the move provide compelling evidence that learning and test scores improve in greener, healthier buildings.

According to Terry Holliday, the Superintendent of the Iredell Statesville Schools (which includes Third Creek Elementary School),

*"Third Creek Elementary School replaced ADR and Wayside Elementary Schools, schools that were two of the district's lowest performing school in regards to test scores and teacher retention/absence. This same group of students and teachers improved from less than 60% of students on grade level in reading and math to 80% of students on grade level in reading and math since moving into the new Third Creek Elementary School. Third Creek had the most gains in academic performance of any of the 32 schools in the school system. We feel that the sustainable approach to this project has had very positive results."<sup>45</sup>*

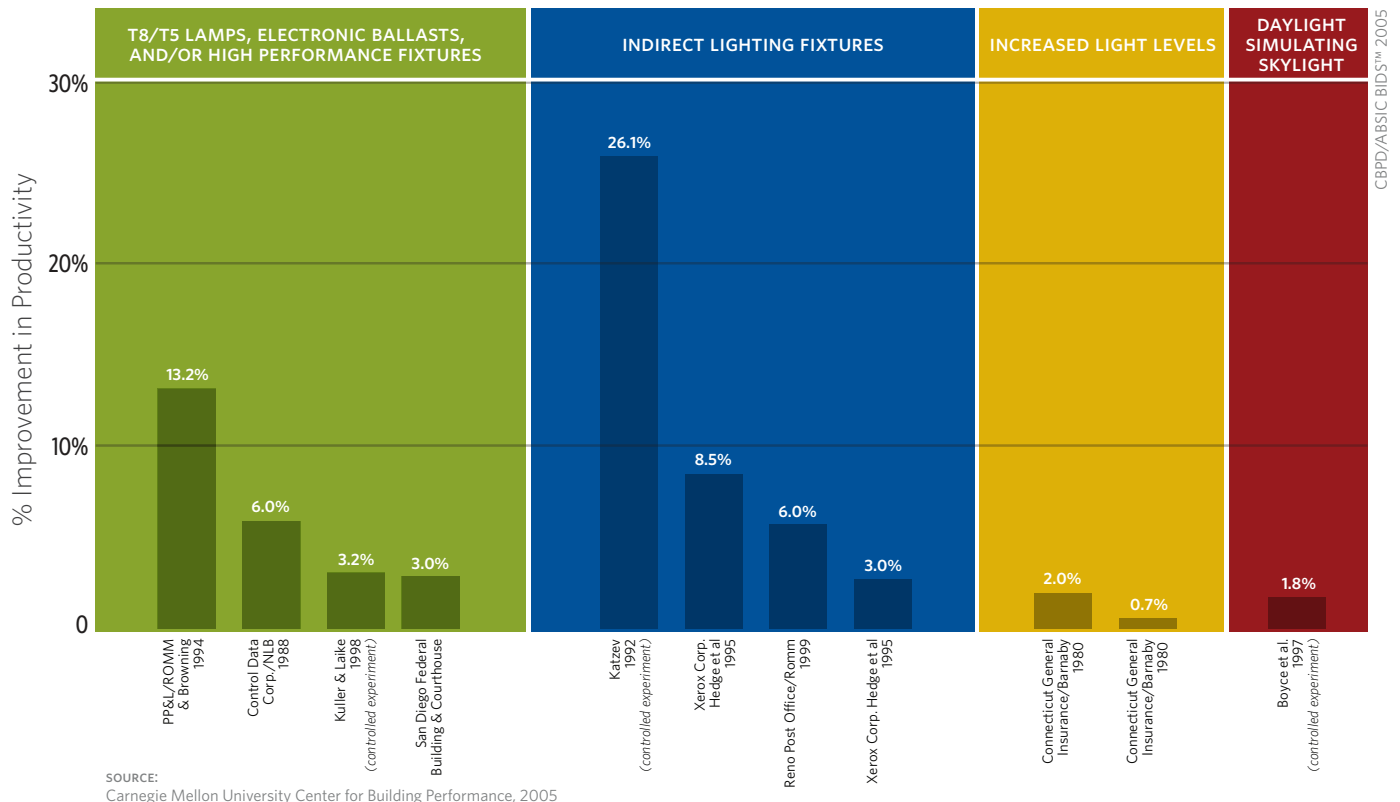
CHPS, LEED and other green school certifications include a range of material, design and operation measures that directly improve human health and productivity. In addition to achieving the related air and comfort quality prerequisites, the 30 green schools



Third Creek Elementary School  
Moseley Architects  
Photo: Spark Productions

FIGURE D

## Productivity Gains from High Performance Lighting Systems



reviewed achieved about half the available indoor environmental quality points from features specifically designed to improve lighting, air quality and comfort.

Based on actual improvements in design in green schools and based on a very substantial data set (some of which is addressed above) on productivity and test performance of healthier, more comfortable study and learning environments, a 3-5% improvement in learning ability and test scores in green schools appears reasonable and conservative. **It makes sense that a school specifically designed to be healthy, and characterized by more daylighting, less toxic materials, improved ventilation and acoustics, better light quality and improved air quality would provide a better study and learning environment.**

**Greening school design is extraordinarily cost-effective compared with other available measures to enhance student performance.**

### Financial Impact of Improved Health and Learning in Green Schools

#### FUTURE EARNINGS

Faster learning and higher test scores are significantly and positively associated with higher lifetime earnings.<sup>46</sup> A 2005 review of the financial benefits of education in an International Monetary Fund (IMF) publication concludes:

*[Recent] studies, which are based on different, nationally representative data sets that follow students after they leave the education system and enter the labor force, provide remarkably similar estimates: one standard deviation increase (moving from the average of the distribution to the 84th percentile) in mathematics performance at the end of high school translates into 12 percent higher annual earnings — an earnings gain that can be expected across the entire working life of the individual. And there are reasons to believe that these estimates provide a lower bound on the effect of higher educational achievement.<sup>47</sup>*

An increase in test scores from 50% to 84% is associated with a 12% increase in annual earnings. As discussed earlier, a smaller improvement in test scores can be conservatively expected from high performance schools compared with conventional schools – in the range of 3% to 5%. Based on the IMF analysis cited above, a 3-5% improvement in learning and test scores is equivalent to a 1.4% lifetime annual earnings increase.

With average annual salary of about \$38,000 per year, this improvement in learning and test scores implies an earnings increase of \$532 per year for each graduate from a green school. We are assuming, conservatively, that the earnings benefits last only 20 years, even though studies indicate they last for the employment lifetime of about 40 years. Assuming that earnings rise only at the rate of inflation, the present value is about \$6,800 per student, or about \$49 per ft<sup>2</sup>. (At a marginal combined federal state and local taxes rate of 40% this indicates an NPV over 20 years of additional tax revenue of \$2,700 per student, or \$20/ft<sup>2</sup>. If one-third of students move to other states, state-specific employee earnings benefits decline to an estimated 20 year financial benefit of about \$33/ft<sup>2</sup>.)

Increases in earning represent the single largest financial benefit from building healthier, more productive learning environments. Greening school design is extraordinarily cost-effective compared with other available measures to enhance student performance.

### FINANCIAL BENEFITS OF ASTHMA REDUCTION

Asthma is a widespread and worsening disease among school children.<sup>48</sup> The American Lung Association has found that American school children miss more than 14 million school days a year because of asthma exacerbated by poor indoor air quality.<sup>49</sup> Nationally, about one in ten of all school children suffer from asthma.

An American Lung Association 2005 Fact Sheet on Asthma and Children notes that:

- Asthma is the most common chronic disorder in childhood, currently affecting an estimated 6.2 million children under 18 years; of which 4 million suffered from an asthma attack or episode in 2003.<sup>50</sup>
- Asthma is the third leading cause of hospitalization among children under the age of 15, and it disproportionately affects children.
- The annual direct health care cost of asthma is approximately \$11.5 billion, with additional indirect costs (e.g. lost productivity) of another \$4.6 billion.<sup>51</sup>

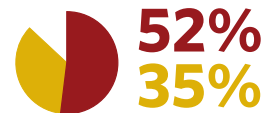
It costs nearly three times more to provide health care for a child with asthma than a child without asthma.<sup>52</sup> In 2006 dollars this amount is equal to \$1,650 per child.<sup>53</sup> Note that most of these health costs are not borne by the schools but rather by the students and their families.

A recent review by Carnegie Mellon of five separate studies evaluating the impact of improved indoor air quality on asthma found an average reduction of 38.5% in asthma in buildings with improved air quality.<sup>54</sup>

We assume the impact of a shift from an unhealthy, conventional school to a healthy school results in a reduction in asthma incidence of 25%. In an average sized new school of 900 students, a 25% reduction in asthma incidence in a healthy school translates into 20 fewer children a year with asthma, with an associated annual cost savings of \$33,000.<sup>55</sup> Over 20 years, and assuming costs of medical treatment continue to rise at the recent historical rate of 5% per year,<sup>56</sup> at a 7% discount rate this translates into a benefit of over \$3/ft<sup>2</sup>. A small portion of this benefit would accrue directly to the school in the form of reduced need for nurse care and staff time, while the rest would benefit families and the larger community through reduced health-care needs. This calculation underestimates the asthma reduction benefits since it does not reflect health improvements in school faculty and staff, which are only partially captured in the analysis on faculty retention impact below.

FIGURE E  
**Benefits of Green K-12 Facilities**

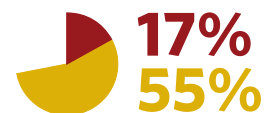
Executive Views on Green School Performance Compared with Conventional Schools



Community Image



Ability to Attract/Retain Teachers



Reduced Student Absenteeism



Student Performance

● Much Better    ● Somewhat Better

SOURCE:  
Turner Construction Company 2005 Survey of Green Buildings

**A recent review of five separate studies found an average asthma reduction of 38.5% in buildings with improved air-quality.**

## COLDS AND FLU REDUCTION

Improved ventilation and air quality reduces a range of respiratory illnesses, including common colds and influenza. A review by Carnegie Mellon of two studies evaluating the impact of improved indoor air quality on colds and flu found an average reduction of 51% in buildings with improved air quality.<sup>57</sup> A major review of the literature by Lawrence Berkeley National Laboratory estimates that better ventilation and indoor air quality would reduce these illnesses by 9-20% in the general population, result in 16-37 million fewer cases of the cold and influenza and provide annual savings of \$6-14 billion.<sup>58</sup> The average impact of \$10 billion, adjusted to 2006 dollars is \$13 billion,<sup>59</sup> or about \$45 per person per year.

We assume for this study that the impact on children is the same as on adults. This may be a conservative assumption (i.e., it underestimates benefits of green schools for students) because children are more susceptible to the transmission of flu and colds. Adults typically earn much more than children, so the direct cost of a child's illness is far less than for an adult. However, a child sick from school commonly either obligates a parent to stay home from work or pay for childcare to attend the sick child, and is economically disruptive. These secondary costs of children's illness are large. Better ventilation and indoor air quality in high performance schools can therefore be estimated to cut costs per pupil from reduced cold and influenza by approximately \$45 per student per year. Over 20 years, and assuming costs of illness continue to rise at the recent historical rate of 5% per year, the present value of reduced incidence of influenza and colds in green schools is over \$5/ft<sup>2</sup>. As noted above for asthma, a small portion of this benefit would accrue directly to the school.

## TEACHER RETENTION

Teachers commonly express concern about school facilities and highlight the issues that green design addresses - lighting quality, temperature control, indoor air quality, etc.

Average salary and benefits for public school teachers can be conservatively estimated at \$65,000.<sup>60</sup> A recent report on the impact of green schools in Washington State estimated a 5% reduction in teacher turnover.<sup>61</sup> Cost of turnover is variously estimated to be 25% up to 200% of annual salary plus benefits (this includes costs of termination, hiring, loss of learning, etc).<sup>62</sup> If we assume a 3% reduction in teacher turnover and the relatively conservative estimate that the cost of teacher loss is 40% of salary and benefits - about \$25,000, then a 3% increase in teacher retention (at an average estimated 2,300 ft<sup>2</sup> of school space per teacher) translates into a financial savings of about \$4/ft<sup>2</sup> over a 20 year period from increased teacher retention.

## Employment Impacts of Green Schools

One of the reasons for the adoption of green construction requirements by cities and states is to increase employment. For example, employment benefits are one of the reasons that the New York City Council passed legislation in September 2005 requiring that significant new construction be built green.<sup>63</sup>

A coalition of labor movements, public entities, NGOs and businesses, called the Apollo Alliance, is advocating an ambitious national clean investment program. An Apollo Alliance analysis models a \$300 billion national investment over a decade in high performance green buildings, rebuilding public infrastructure, increasing energy efficiency and investing in industries of the future (such as clean technologies), and concludes that this would create 3.3 million jobs.<sup>64</sup> A 2004 report by Black & Veatch on the impact of establishing a minimum energy consumption target for Pennsylvania of 10% from renewables over 20 years would, compared to business as usual, generate a net increase of \$10.1 billion in economic output, increase earnings in state by \$2.8 billion and result in 20,000 more jobs.<sup>65</sup>

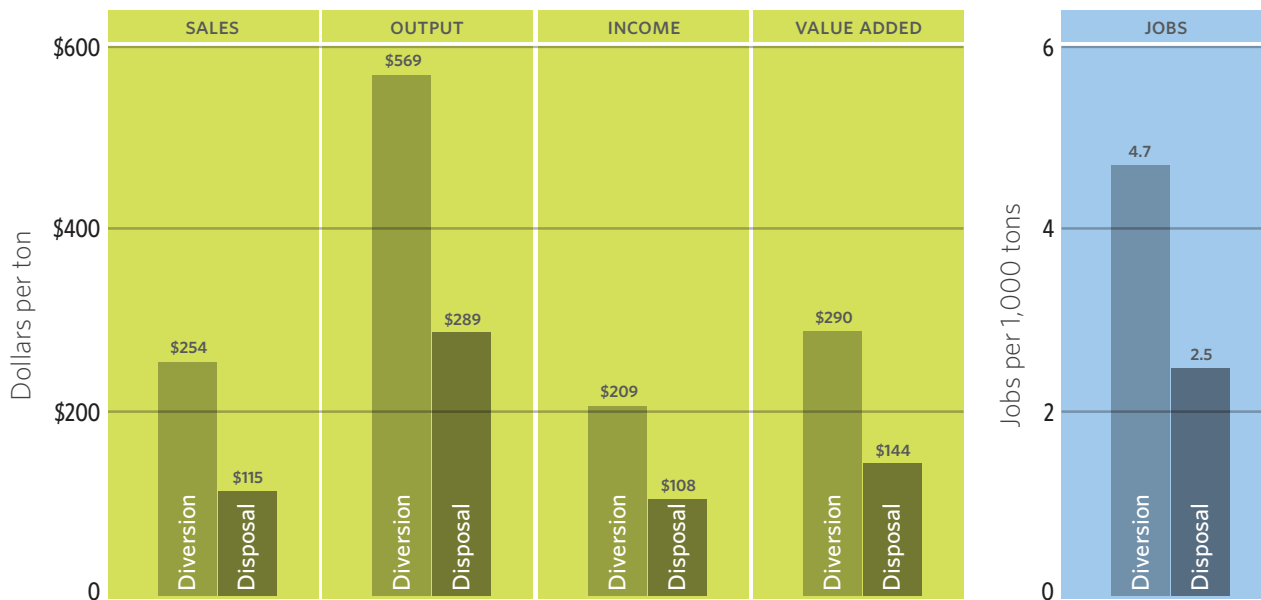


**Clearview Elementary School**  
John Boecker, Architect with L. Robert Kimball & Assoc.  
Photo: Jim Schafer Location Photography



FIGURE F

## Job Impacts of Waste Diversion vs Disposal



SOURCE:  
Goldman and Ogishi, UC Berkeley, 2001

Green buildings typically involve greater initial costs to achieve important green objectives such as improved energy efficiency, increased use of renewable energy (on site and off site), and diversion of waste from landfills for reuse or recycling. These changes create local and US jobs and offset wasteful consumption of energy (some of it imported from anti-democratic nations) and improve productivity and the US trade deficit. Each of these aspects of green design - efficiency, renewable energy and waste diversion — involves increased employment compared with conventional non-green buildings.

### ENERGY EFFICIENCY

The typical green school uses one-third less energy than conventional schools. This reduction is a result of a combination of things, including better design, more energy efficiency equipment, and installation of energy efficiency measures such as increased insulation.

A 2004 Massachusetts report found that every \$10 million in additional energy efficiency investments contributes about 160 short-term jobs and 30 long-term or permanent jobs. Assuming about \$200,000 in additional energy efficiency related investments in a green school relative to a conventional school, investment in energy efficiency creates three short-term jobs through additional work and half of a long-term job per school.<sup>66</sup>

The average income for a permanent job created can be conservatively estimated as \$38,000,<sup>67</sup> indicating a long-term annual increase in salary in-state for each green school of \$19,000 (half of one fulltime job created from increased energy efficiency). On a 20 year discounted basis, and assuming salaries grow at inflation, this is \$250,000 of direct in-state salary created, equal to \$2/ft<sup>2</sup> for a typical 125,000 ft<sup>2</sup> school. This calculation does not include the positive net employment impact of short-term jobs created.

**Only 2.5 jobs are created for every 1,000 tons of waste disposed, while 4.7 jobs are created for 1,000 tons of waste diverted.**



**Newberg High School**  
Boora Architects  
Photo: Michael Mathers

**75% of senior executives believe that being green improves a school's ability to attract and retain teachers.**

### INCREASED USE OF RENEWABLE ENERGY

Green buildings generally use more renewable energy, both on site and off site, than conventional buildings, primarily from purchase of green power and renewable energy credits. Use of renewable energy generally displaces less labor intensive and more polluting energy sources such as imported heating oil, gas, and coal burned in power plants to make electricity.

A shift to more renewable energy would also increase employment. Compared with a business as usual energy growth mix, expanding renewable energy use to 20% nationally by 2020 would create roughly 100,000 net new jobs nationally. The majority of these jobs would be in manufacturing and construction, and would be relatively well paid and broadly distributed (all states would experience positive employment growth) and would particularly benefit sectors of the economy suffering relatively high unemployment.<sup>68</sup>

It is beyond the scope of this report to estimate the positive employment benefit from increased use of renewable energy in green schools. This increase in employment is expected to be significant, so not calculating it underestimates the financial benefits of requiring that schools be green.

### WASTE DIVERSION

A third way that green schools increase employment is by diverting waste from landfills to more labor intensive activities such as separation and recycling.

A recent UC Berkeley study found that total economic impacts from diversion are nearly twice as large as the impacts from sending these materials to dumps. One ton of waste diverted to reuse/recycling generates about twice the employment impact of a ton of waste disposed in a landfill. Only 2.5 jobs are created for every 1,000 tons of waste disposed, while 4.7 jobs are created for waste diverted as recyclables (See Figure F).<sup>69</sup>

A comprehensive Massachusetts study on the environmental benefits of recycling calculated that the total benefits per ton were \$151-\$331.<sup>70</sup> As noted above, the UC Berkeley study found that diversion was about two times as labor intensive as disposal. This report does not calculate the employment benefits of increased diversion in green schools, but they appear substantial.

### CONCLUSION ON EMPLOYMENT IMPACTS

Clearly green schools create more jobs than conventional schools. Most energy used in schools comes from burning fossil fuels, some of which is imported from countries that fund terrorism. Thus, the shift to more energy efficiency, which includes in-state manufacturing, system design and installation labor for insulation, renewable energy systems, better windows, etc., would have significant positive employment, economic and security impacts. This report calculates only one of these — long-term employment impact of increased energy efficiency - and it is found to provide \$2/ft<sup>2</sup> of benefits.

### Additional Non-Quantified Benefits

Green schools provide a range of additional benefits compared with conventional schools. Some of these are discussed below.

#### REDUCED TEACHER SICK DAYS

Improved air, comfort and health in green school buildings positively affect teachers. As discussed above, improved lighting, ventilation and indoor environmental quality significantly improve measured health and productivity benefits for workers in buildings. As indicated in Figure E, three quarters of senior executives interviewed for the 2005 Turner Construction survey believe that being green improves the school's ability to attract and retain teachers. A PhD thesis on the Clearview Elementary School (See Table B), a 2002 LEED gold building in Pennsylvania, found that teachers experience 1.41 fewer missed working days, a 12% decrease from previous traditional school.<sup>71</sup> If teachers

experience a 7% decrease in sick days in green schools — one day a year less because of healthy air and a better work environment — the reduced cost of substitute teachers provides a present value of about \$2/ft<sup>2</sup>. Conservatively, this benefit is not included in this report.

### HEAT ISLAND REDUCTION MEASURES

Non-reflective building surfaces absorb more sunlight, increasing temperature within buildings, as well as on exterior surfaces. In cities this effect creates urban “heat islands” and an associated need for increased air conditioning. Non reflective (typically dark) roofs can be substituted with reflective roofs or green, planted roofs — collectively known as “cool roofs” — and significantly reduce city or local temperature as light/heat is reflected back into space rather than absorbed and radiated locally. By reducing ambient urban temperatures, heat island reduction directly contributes to reduced ozone creation, in turn reducing the large human health costs associated with smog. In addition to positive energy and heat island impacts, cool roofs also experience less expansion and contraction than non-reflective roofs, which contributes to a significant extension of the roof life. Typically, highly reflective roofs last 20% longer than conventional roofs.<sup>72</sup> Green roofs (with plants in soil on an impermeable membrane) are expected to last 30-50 years or longer.

Lowered ambient air temperature cuts smog formation, improves comfort and health and cuts the cost of air conditioning. The financial benefits of this aspect of greening schools are substantial but are not quantified here.

### LOWER OPERATIONS AND MAINTENANCE (O&M) COSTS

A major recent study of costs and benefits of green buildings for 40 state agencies found that the operations and maintenance (O&M) benefits of greening California public buildings provide savings worth \$8/ft<sup>2</sup> over a 20 year period.<sup>73</sup> Green schools, like other green buildings, incorporate design elements such as commissioning and more durable materials that reduce O&M costs. For example, the Canby School in Oregon, designed by Boora Architects, (see *Table B*) at a level equivalent to LEED Gold, features exterior surfaces of brick and metal with a baked finish that require virtually no maintenance/painting, as well as a linoleum floor with lower maintenance than conventional flooring.<sup>74</sup> Estimating O&M benefits from green schools is beyond the scope of this study but the benefits are probably significant.

### ENHANCEMENT OF GENERATING SYSTEM RELIABILITY AND IMPROVED POWER QUALITY

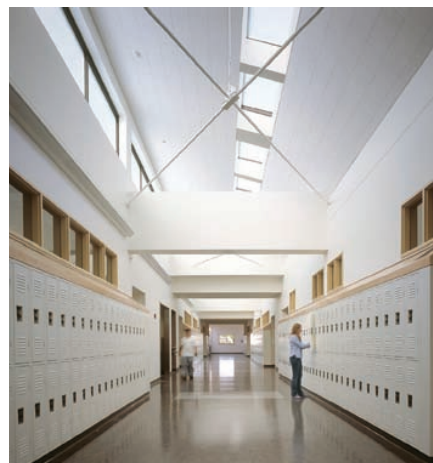
The benefits for businesses and competitiveness from improved power quality resulting from greater energy efficiency can be large. National annual cost of power quality problems and outages have been estimated by the New York State Energy Research and Development Authority and the Electric Power Research Institute at over \$100 billion.<sup>75</sup> Power quality concerns are a significant issue for many businesses, and energy efficiency and renewable energy provide an important way to reduce power quality and reliability costs.

The Massachusetts Division of Energy Resources 2004 Annual Report on Energy Efficiency activities notes that:

*By reducing demand, the energy efficiency programs contribute to system reliability in terms of supply adequacy within a particular area or region... all energy efficiency measures... help maintain adequate margins of generation supply, and can help deter brownouts and blackouts....By reducing load and demand on the power distribution network, the [efficiency] programs decrease the costly likelihood of failures.<sup>76</sup>*

*This report does not quantify the power quality and reliability economic benefits of greening the nation's schools, but they appear substantial.*

**Research has shown that it costs less to recycle most construction and demolition waste than to dispose of it.**



**North Clackamas High School**  
Note entirely day-lit corridor.  
Heinz Rudolf, Boora Architects  
Photo: Michael Mathers

## Greening public schools creates an opportunity to improve the health and educational settings for all students.

The financial benefits of greening schools are about \$70 per ft<sup>2</sup>, more than 20 times as high as the cost of going green.

### CONSTRUCTION & DEMOLITION WASTE REDUCTION BENEFITS OF GREEN SCHOOLS

About 25% of the solid waste discarded nationally is construction and demolition (C&D) waste, adding up to 130 million tons of waste per year.<sup>77</sup> Fifty-seven percent of national C&D waste comes from non-residential building projects,<sup>78</sup> deriving from three sources:<sup>79,80</sup>

- demolition, which creates about 155 pounds of waste per square foot, and makes up 58% of national non-residential C&D waste;
- construction, which creates about 3.9 pounds of waste per square foot, and makes up 6% of national non-residential C&D waste;
- renovation, which makes up 36% of national non-residential C&D waste.

Research has shown that it actually costs less to recycle most C&D waste than to dispose of it. A rigorous 1999 study found that for all construction and demolition wastes (including mixed debris), the cost of recycling is less than the cost of disposal by at least 35%.<sup>81</sup>

C&D diversion rates are typically at least 50-75% in green buildings and have reached as high as 99% on some projects.<sup>82</sup> The green schools studied in this report have an average C&D diversion rate of 74%. The financial benefits of increased waste diversion are not estimated here but appear significant.

### INSURANCE AND RISK RELATED BENEFITS

Health related benefits from green schools have significant risk and insurance impacts. For example, according to the Chief Economist at the Insurance Information Institute, most insurers reported a tripling of mold-related claims in 2002. By early 2003, more than 9000 claims related to mold were pending the nation's courts, though most involve family homes.<sup>83</sup> Improved ventilation and greater commissioning in green buildings reduces the likelihood of mold and associated liability problems.

The Kats/California study characterized the potential insurance benefits of green buildings by mapping risk and insurance related benefits onto the credits of the LEED system. Each LEED prerequisite and credit was evaluated against seven types of risk: property loss, general liability, business interruption, vehicular, health & workers

## INSURANCE BENEFITS OF GREEN BUILDINGS

- Worker Health & Safety. Various benefits, including lower worker's compensation costs, arise from improved indoor environmental quality, reduced likelihood of moisture damage, and other factors enhancing workplace safety.
- Property Loss Prevention. A range of green building technologies reduce the likelihood of physical damages and losses in facilities.
- Liability Loss Prevention. Business interruption risks can be reduced by facilities that derive their energy from on-site resources and/or have energy-efficiency features. These risks include those resulting from unplanned power outages.
- Natural Disaster Preparedness and Recovery. A subset of energy efficient and renewable energy technologies make facilities less vulnerable to natural disasters, especially heat catastrophes.

comp, life, and environmental liability. Of the 64 LEED points available (not including innovation credits) 49 (77%) are associated with measures that have potential risk-reduction benefits.

Insurance-related benefits of green, high performance design are summarized on page 18 (and reproduced from the Kats/California study). This report does not estimate the value of the risk and liability reduction benefits of green buildings.

### IMPROVING EQUITY AND ADDRESSING SPIRITUAL VALUES

Lower income and minority children disproportionately suffer from poor indoor air quality and related problems in conventional schools. Children in low income families are 30% to 50% more likely to have respiratory problems such as asthma and allergies that lead to increased absenteeism, and diminished learning and test scores. This increase in respiratory problems results in large part from exposure to polluted and unhealthy air and study conditions in schools and at home. Wealthy families can move their children into better designed and healthier private schools. Less affluent families are less likely to have that luxury. Greening public schools creates an opportunity to improve the health and educational settings for all students, regardless of income or background, a process with clear moral benefits. The financial benefits of a less inequitable educational system are difficult to calculate but could be substantial in terms of increased diversity in the work force, community development, increased productivity, etc.

Many people are spiritual and religious, and value environmental richness and environmental protection as an important spiritual issue. For example, a recent Le Moyne College/Zogby International Contemporary Catholic Trends Poll found that 87% of those polled said that protecting the environment is an important issue, with 21% placing it as “the most important issue” facing America today.<sup>84</sup> For many Americans, protecting the environment and God’s creatures by cutting energy waste and air and water pollution is a very important part of their religious and spiritual value system.

While spiritual, religious and moral values are difficult to quantify they are important and are relevant for school design choices.

### EDUCATIONAL ENRICHMENT AS AN ASPECT OF GREENER, HEALTHIER FACILITIES

High performance schools provide hands-on educational opportunities that conventional schools do not. For example, on site renewable energy generation, water conservation features and other green technologies provide very valuable opportunities for hands-on learning. Sidwell Friends, a highly regarded Quaker affiliated school in Washington DC, is making greening a principal objective in its campus renovation and expansion. The ongoing effort to make the school’s building more environmentally-friendly and healthy provides a rich source of hands-on educational material for both full time and summer students. Mike Saxenian, Assistant Head of the School and Chief Financial Officer says that “students have responded with enthusiasm to the school’s decision to build green, and faculty are eager to use the new facilities as a laboratory to demonstrate solutions to environmental problems discussed in class. Trustees, faculty and administrators see the green building program as an affirmation of the school’s core values.”<sup>85</sup>

### SUMMARY OF ADDITIONAL BENEFITS

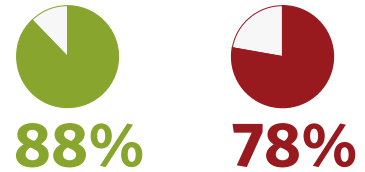
These additional benefits of greening schools — including reduced teacher sick days, lower operations and maintenance costs, improved electricity quality and reliability, reduced insurance and risk related costs, and improved educational quality — are all substantial benefits that are not quantified in this study. These additional benefits, if calculated, would greatly increase the recognized financial benefits of greening schools and further strengthen the case that building conventional relatively inefficient and unhealthy school buildings today is financially imprudent and even irresponsible.

## FIGURE G Executives' Views of Green Building Benefits

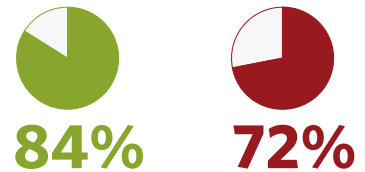
Percent of Executives Saying Green Buildings are Superior to Conventional Buildings

Organizations Involved with Green Buildings | Organizations Not Involved with Green Buildings

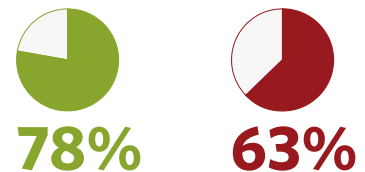
### Health & Well-being of Occupants



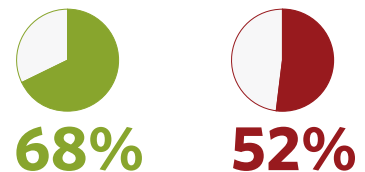
### Buildings Value



### Worker Productivity



### Return on Investment



SOURCE:  
Turner Construction Company 2005 Survey of Green Buildings

**Greening schools today is extremely cost-effective, and represents a fiscally far better design choice.**

**NOTE ON IMPACT OF INCREASED EXPERIENCE WITH GREEN BUILDINGS**

There is a learning curve associated with designing and building green schools. For both public and private owners and developers of green buildings, subsequent green buildings generally cost less than the first. The trend of declining costs associated with increased experience in green building construction has been experienced in Pennsylvania,<sup>86</sup> as well as in Portland and Seattle. Portland’s first three reported completed LEED Silver buildings incurred cost premiums of 2%, 1% and 0% respectively.<sup>87</sup> Seattle saw the cost premium of LEED Silver buildings drop from 3-4% to 1-2%.<sup>88</sup>

Similarly, a recent survey by the national construction firm, Turner Construction, found that the recognized benefits of green building in a range of areas, (including health benefits and productivity) increase significantly as they gain experience with green buildings (see *Figure G*).

For example, 78% of executives in organizations not involved with green building believe that greening a building improves health and well being of occupants, while 88% of executives in organizations with experiences of green buildings hold this view. Thus, increased experience with green buildings both reduces costs of building green and increases the recognized benefits of green design. For school districts considering greening their schools, these trends highlight the large educational and financial benefits of greening both new and existing schools.

<b>Financial Benefits of Green Schools (\$/ft<sup>2</sup>)</b>	
Energy	\$9
Emissions	\$1
Water and Wastewater	\$1
Increased Earnings	\$49
Asthma Reduction	\$3
Cold and Flu Reduction	\$5
Teacher Retention	\$4
Employment Impact	\$2
<b>Total</b>	<b>\$74</b>
<b>Cost of Greening</b>	<b>(\$3)</b>
<b>Net Financial Benefits</b>	<b>\$71</b>

**CONCLUSIONS**

Greening school design is extremely cost-effective. Green schools cost on average almost 2% more, or \$3 more per ft<sup>2</sup>, than conventional schools. The financial benefits of greening schools are about \$70 per ft<sup>2</sup>, more than 20 times as high as the cost of going green. Only a portion of these savings accrue directly to an individual school. Lower energy and water costs, improved teacher retention, and lowered health costs save green schools directly about \$12/ft<sup>2</sup>, about four times the additional cost of going green, and enough to hire an additional full-time teacher.

Analysis of the costs and benefits of 30 green schools and use of conservative and prudent financial assumptions provides a clear and compelling case that greening schools today is extremely cost-effective, and represents a fiscally far better design choice. Building green schools is more fiscally prudent and lower risk than continuing to build unhealthy, inefficient schools.

“High performance, cost effective schools begin with good design. As this study details, nowhere is good design more important than for our schools. Enhanced learning environments that are also environmentally responsible continue to be an ongoing focus of AIA awards programs and government advocacy. But, as the study makes clear, all schools must also be green. Members of The American Institute of Architects believe good design makes a difference. This study underscores the enormous costs of poor design, and the critical impact that good design and operation has on the quality of our children’s education. It deserves widespread consideration if we are to properly prepare students to address the environmental challenges of our new century.”

— *Kate Schwensen, President, The American Institute of Architects*



**North Clackamas High School**  
Heinz Rudolf, Boora Architects  
Photo: Michael Mathers





## Endnotes

- 1 This report draws extensively on two recent studies of the costs and benefits of green schools and green buildings: Kats, Greg et al. "National Review of Green Schools: Costs, Benefits and Implications for Massachusetts," a report for the Massachusetts Technology Collaborative (MTC), 2005. Principal Author Greg Kats, Capital E, contributing author Jeff Perlman, Capital E, contributing researcher Sachin Jamadagni, MTC. And Kats, Greg et al. "The Costs and Financial Benefits of Green Buildings," a report to California's Sustainable Building Task Force, 2003. Principal Author: Greg Kats, Capital E, Contributing Authors: Leon Alevantis, Department of Health Services, Adam Berman, Capital E, Evan Mills, Lawrence Berkeley National Laboratory "(on insurance issues)" and Jeff Perlman, Capital E. Task Force Chair: Arnie Sowell. Available at [www.cap-e.com](http://www.cap-e.com).
- 2 "2005 Survey of Green Buildings," Turner Construction. Available at: <http://www.turnerconstruction.com/greenbuildings>
- 3 7% (e.g., 5% real plus inflation) is consistent with the Kats/California Report and is higher (more conservative) than the "Washington High Performance School buildings: Report to the Legislature," which used 5% discount rate. (Washington State Board of Education and Office of the Superintendent of Public Instruction, prepared by Paladino & Company, January 2005)
- 4 The Wall Street Journal lists discount rates daily, dependent upon credit rating. See Market Data and Resources: [http://online.wsj.com/public/site\\_map?page=Site+Map](http://online.wsj.com/public/site_map?page=Site+Map). See also: [http://oregonstate.edu/Dept/pol\\_sci/fac/sahr/cf166503.pdf](http://oregonstate.edu/Dept/pol_sci/fac/sahr/cf166503.pdf) and <http://www.jsc.nasa.gov/bu2/inflateGDP.html>.
- 5 Collaborative for High Performance Schools <http://www.chps.net>
- 6 MA Collaborative for High Performance Schools: [http://www.mtpc.org/RenewableEnergy/green\\_schools/chps\\_standards.htm](http://www.mtpc.org/RenewableEnergy/green_schools/chps_standards.htm) Also see: [http://www.mphaweb.org/pol\\_schools\\_green.html](http://www.mphaweb.org/pol_schools_green.html) for valuable set of resources
- 7 O'Brien & Company, Inc. and Olympic Associates, Inc. "Washington Sustainable Schools Program - Phase 2. Pilot Project - Final Report."
- 8 See: <http://www.peterli.com/global/pdfs/SPMConstruction2006.pdf>, [http://asumag.com/mag/university\\_stalled\\_momentum/](http://asumag.com/mag/university_stalled_momentum/) and also see: <http://www.edfacilities.org/cd/dodge0606.pdf>
- 9 Data supplied by the architects except for \* - from Doug Sacra, HMFH Architects, November 2005. See: Kats, et al 2005.
- 10 Personal communication with architect Kevin Hall, OWP/P.
- 11 "Green City Buildings: Applying the LEED Rating System," Prepared for the Portland Energy Office by Xenergy Inc, and Sera Architects, June 18, 2000.
- 12 See: [http://asumag.com/mag/university\\_coming\\_short/](http://asumag.com/mag/university_coming_short/)
- 13 See: <http://www.eia.doe.gov/cneaf/electricity/epm/tablees1b.html>
- 14 Wisner, Ryan, Mark Bolinger and Matt St. Clair. "Easing the Natural Gas Crisis: Reducing Natural Gas Prices through Increased Deployment of Renewable Energy and Energy Efficiency." Lawrence Berkeley National Laboratory, January 2005. p. 40. <http://eetd.lbl.gov/EA/EMP>
- 15 "Hedging Energy Price Risk With Renewables and Energy Efficiency," Platts Research & Consulting Sept, 2004
- 16 O'Connor, David, Commissioner of the Division of Energy Resources and Beth Lindstrom, Director of the Consumer Affairs and Business Regulation Agencies, "2002 Energy Efficiency Activities Report by the Division of Energy Resources," Summer 2004, Office of Consumer and Business Affairs, Commonwealth of Massachusetts.
- 17 See, for example: "The Benefits and Costs of Clean Air Act 1990 to 2010," 1991, <http://www.epa.gov/air/sect812/1990-2010/fullrept.pdf>; and Jonathan Samet et al., "The National Morbidity, Mortality, and Air Pollution Study - Part II: Morbidity and Mortality" from Air Pollution In the United States, Health Effects Institute, 2000, <http://www.healtheffects.org/Pubs/Samet2.pdf>.
- 18 The calculations below are based on electricity consumption of 8.57 kwh per square foot per year, gas consumption of 0.38 therms per square foot per year, and a total school space of 125,000 square feet. See Kats et al 2005.
- 19 Assumes 4% annual increase in cost/value of emissions. For more detailed description of emissions reductions calculations see Kats, Greg et al 2005; and the Ozone Transport Commission's Emission Reduction Workbook: <http://www.otcair.org/download.asp?FID=69&Fcat=Documents&Fview=Reports&Ffile=Workbook%202.1%20Manual.pdf>
- 20 "Climate Change Futures Health, Ecological and Economic Dimensions," Harvard Medical Schools, November 2005. [http://www.climatechange-futures.org/pdf/CCF\\_Report\\_Final\\_10.27.pdf](http://www.climatechange-futures.org/pdf/CCF_Report_Final_10.27.pdf)
- 21 Intergovernmental Panel on Climate Change. World Meteorological Association and United Nations Environmental Program. "IPCC Third Assessment Report - Climate Change 2001." Available at: <http://www.ipcc.ch/> Global surface temperature has increased 1/3 degree F in each of the last three decades. See: Hansen, James, et al. "Global Temperature Change," Proceedings of the National Academy of Sciences. September 2006. <http://www.pnas.org/cgi/reprint/0606291103v1>
- 22 Oreskes, Naomi. "The Scientific Consensus on Climate Change," Science. 305:1686 December 2004. <http://www.sciencemag.org/cgi/content/full/306/5702/1686>
- 23 See Hell and High Water, Joseph Romm, forthcoming from William Morrow, publisher, January 2007. The book provides a very valuable and readable account of global warming science, impacts and politics. A valuable review of the science and impact of global warming is provided by James Hansen NASA's top climate scientist: [http://www.columbia.edu/~jeh1/keeling\\_talk\\_and\\_slides.pdf](http://www.columbia.edu/~jeh1/keeling_talk_and_slides.pdf). Also see: James Hansen, "Answers about the Earth's energy Imbalance," 2005 [www.earthinstitute.columbia.edu/news/2005/story11-04-05.html](http://www.earthinstitute.columbia.edu/news/2005/story11-04-05.html). Also, <http://www.climateprogress.org> provides daily news updates on climate related science, policy and current events.
- 24 For example, Cheyne Capital Management Limited, one of Europe's largest Hedge Funds, is buying high quality verified carbon emission reductions and selling them to financial firms and corporations in the US and Europe that want to manage and reduce their climate change impact. [www.cheynecapital.com](http://www.cheynecapital.com)
- 25 HMFH Architects, Inc. and Vermont Energy Investment Corp. "The Incremental Costs and Benefits of Green Schools in Massachusetts," MTC, 2005.
- 26 The Clean Water and Drinking Water Infrastructure Gap Analysis. Published by the EPA, August 2002. <http://www.epa.gov/safewater/gapreport.pdf>.
- 27 Renzetti, Steven. "Municipal Water Supply and Sewage Treatment: Costs, Prices, and Distortions." Canadian Journal of Economics, May 1999. Available at: <http://economics.ca/cje/>
- 28 "An Environment for Learning," American Federation of Teachers, April 21, 2004. [http://www.aft.org/presscenter/speeches-columns/wvs/2004/WWS\\_0404.pdf](http://www.aft.org/presscenter/speeches-columns/wvs/2004/WWS_0404.pdf). Also see: "School Facilities: America's Schools not Designed or Equipped for the 21st Century", General Accounting Office Report # HEHS-95-95. See also: "IAQ and student performance", Environmental Protection Agency, revised August 2003 [http://www.epa.gov/iaq/schools/images/iaq\\_and\\_student\\_performance.pdf](http://www.epa.gov/iaq/schools/images/iaq_and_student_performance.pdf)
- 29 US Environmental Protection Agency, "Indoor Air Quality," January 6, 2003. Available at: <http://www.epa.gov/iaq/>.
- 30 Mendell and Heath, "Do indoor pollutants and thermal conditions in schools influence student performance? A critical review of the literature" Indoor Air, Vol. 15, p. 27, 2004. Also see: "Do School Facilities Affect Academic Outcome?" National Clearinghouse for Educational Facilities, Mark Schneider, November 2002. Available at [www.edfacilities.org](http://www.edfacilities.org)
- 31 Heerwagen, Judith. "Sustainable Design Can Be an Asset to the Bottom Line - expanded internet edition," Environmental Design & Construction, July 2002.
- 32 Loftness, Vivian et al. "Building Investment Decisions Support (BIDS)," ABSIC Research 2001-2002 Year End report. Available at: <http://nodem.pc.cc.cmu.edu/bids>.
- 33 Data extracted from BIDS Carnegie Mellon University Department of Architecture. Communication with Vivian Loftness, CMU, February 2003, October 2005.
- 34 Schneider, Mark. "Do School Facilities Affect Academic Outcomes?" National Clearinghouse for Education Facilities, November 2002. Available at: [www.edfacilities.org](http://www.edfacilities.org)
- 35 Lowe, JM. "The Interface between educational facilities and learning climate." Texas A&M dissertation, cited in Schneider.
- 36 Study described in a valuable review of green building productivity issues in: Alex Wilson, "Productivity in Green Buildings," Environmental Building News, October 2004.
- 37 Buckley, Jack et al. "Fix it and they will stay: the effects of schools facility quality on teacher retention in urban school districts" Boston College, supported in Part by the Ford Foundation and the 21st Century schools fund. <http://www2.bc.edu/~bucklesj/retention04.pdf>
- 38 Lemasters, LK, "A synthesis of studies pertaining to facilities, student achievement and student behavior," VA Polytechnic, 1997. Cited in Schneider
- 39 "2005 Survey of Green Buildings," Turner Construction. Available at: <http://www.turnerconstruction.com/greenbuildings>
- 40 Illinois Healthy Schools Campaign, "Apparently Size Doesn't Matter: Two Illinois School Districts Show Successful IAQ Management." School Health Watch, Summer 2003. [http://healthyschoolscampaign.org/news/newsletter/2003-summer\\_HSC-newsletter.pdf](http://healthyschoolscampaign.org/news/newsletter/2003-summer_HSC-newsletter.pdf). Also see: US Environmental Protection Agency. "IAQ Tools for Schools," December 2000 (Second Edition). Available at: <http://www.epa.gov/iaq/schools/>.
- 41 Schneider, Mark. "Public School Facilities and Teaching: Washington, DC and Chicago," November 2002. A Report Prepared for the Neighborhood Capital Budget Group (NCBG). Available at: <http://www.ncbg.org/press/press11302.htm>.
- 42 "Washington High Performance School Buildings: Report to Legislature" prepared by Paladino & Company, January 31, 2005
- 43 Personal communication with architect Heinz Rudolf November 2005.
- 44 Personal communication with architect John Boecker, 7Group, November 2005. Also see: "Wesley Doll, "Green Design Experiences: A Case Study," PhD Dissertation for University of Pennsylvania, 2005. The thesis evaluated the impacts on students of the Clearview green school compared to the prior, conventional school.

- 45 From Moseley Architects summary sheet, <http://www.moseleyarchitects.com>
- 46 See for example <http://www.ed.gov/pubs/VoEd/Chapter4/Part6.html>, and [http://portal.unesco.org/education/en/ev.php-URL\\_ID=35945&URL\\_DO=DO\\_TOPIC&URL\\_SECTION=201.html](http://portal.unesco.org/education/en/ev.php-URL_ID=35945&URL_DO=DO_TOPIC&URL_SECTION=201.html)
- 47 Hanushek, Erick. "Why Quality Matters in Education" Finance And Development, International Monetary Fund, June 2005. <http://www.imf.org/external/pubs/ft/fandd/2005/06/hanushek.htm>
- 48 "Trends in Asthma Morbidity and Mortality," American Lung Association, Epidemiology and Statistics Unit, May 2005. Also see: "Pediatric Asthma in Massachusetts 2003-2004," Mass Department of Public Health, Center for Environmental Health, August 2005.
- 49 "Asthma in Children fact sheet." American Lung Association, 2002, [www.lungusa.org/asthma/ascpedface99.html](http://www.lungusa.org/asthma/ascpedface99.html). And, "Indoor Air Quality and Student Performance" US EPA, 2003. [http://www.epa.gov/iaq/schools/images/iaq\\_and\\_student\\_performance.pdf](http://www.epa.gov/iaq/schools/images/iaq_and_student_performance.pdf).
- 50 National Center for Health Statistics. Raw Data from the National Health Interview Survey, U.S., 2003. (Analysis by the American Lung Association in "Asthma and Children Fact Sheet" July 2005 <http://www.lungusa.org/site/pp.asp?c=dvLUK900E&b=44352>)
- 51 National Heart, Lung and Blood Institute Chartbook, U.S. Department of Health and Human Services, National Institute of Health, 2004. See: American Lung Association, "Asthma and Children Fact Sheet," July 2005 at: <http://www.lungusa.org/site/pp.asp?c=dvLUK900E&b=44352>
- 52 "Attacking Asthma. Combating an epidemic among our children." Report to the Senate Committee on Post Audit and Oversight of the Massachusetts Senate, December 2002. Referencing The Economic Burden of Asthma in US Children: Estimates from the National Medical Expenditure Survey." *Journal of Allergy, Clinical Immunology* 1999; 104:957-63 See: <http://www.mass.gov/legis/senate/asthma.htm>
- 53 In 1987 dollars average yearly health costs \$468 for a child without asthma, and \$1129 with asthma, for a difference of \$661. From 1987 to 2006 average health care experienced a 150% price increase, based on a 5% yearly average CPI for medical care. Annual per capita health expenditures grew by an average of 5.5% per year from 1995-2003. From: "Health, United States, 2005" Center for Disease Control. <http://www.cdc.gov/nchs/data/hus/hus05.pdf>
- 54 Carnegie Mellon University Center for Building Performance, 2005. <http://www.arc.cmu.edu/cbpd/index.html>
- 55 25% reduction from the current national student asthma prevalence rate of 9.5%. From "Trends in Asthma Mortality and Morbidity," American Lung Association, 2006. <http://www.lungusa.org/atf/cf/{7A8D42C2-FCCA-4604-8ADE-7F5D5E762256}/ASTHMA06FINAL.PDF>
- 56 Annual per capita health expenditures grew by an average of 5.5% per year from 1995-2003. Source: <http://www.cdc.gov/nchs/data/hus/hus05.pdf> "Health, United States, 2005" Center for Disease Control.
- 57 Carnegie Mellon University Center for Building Performance 2005, <http://www.arc.cmu.edu/cbpd/index.html>
- 58 Fisk, Bill. *Indoor Air Quality Handbook*, McGraw Hill, Lawrence Berkeley National Laboratory, 1999.
- 59 For Health CPI inflator: See: [www.hrsa.gov/osp/dofcr/provide/ppn0401.htm](http://www.hrsa.gov/osp/dofcr/provide/ppn0401.htm)
- 60 Also see: <http://www.aft.org/salary/index.htm>. 2003/2004 salary basis of \$46,597 adjusted to 2006. Benefits assumed conservatively to be 30%. See for example: <http://boston.k12.ma.us/textonly/jobs/teaching.asp#salary>
- 61 "Washington High Performance School Buildings: Report to Legislature" prepared by Paladino & Company, Jan, 2005
- 62 "The Cost of Teacher Turnover" Texas Center for Educational Research, 2000 See: <http://www.sbec.state.tx.us/SBECOnline/txbess/turnoverrpt.pdf>
- 63 See: [http://www.nyccouncil.info/pdf\\_files/newswire/greenbuildings.pdf](http://www.nyccouncil.info/pdf_files/newswire/greenbuildings.pdf)
- 64 "The Apollo Jobs Report: For Good Jobs & Energy Independence New Energy for America." See: <http://www.apolloalliance.org/docUploads/ApolloReport.pdf>
- 65 "Economic Impact of Renewable Energy in Pennsylvania", Black & Veatch, March 2004
- 66 Based on the analysis by the Massachusetts Division of Energy Resources and the Consumer Affairs and Business Regulation Agencies. See Kats et al., 2005
- 67 "May 2005 National Occupational Employment and Wage Estimates," US Department of Labor, Bureau of Labor Statistics. [http://www.bls.gov/oes/current/oes\\_nat.htm#b00-0000](http://www.bls.gov/oes/current/oes_nat.htm#b00-0000)
- 68 Kammen et al, UC Berkeley, "Putting renewables to work: How many jobs can the clean energy industry generate?" Energy Resources Group, University of California at Berkeley, April 2004. <http://rael.berkeley.edu/files/2006/Kammen-Renewable-Jobs-2006.pdf>
- 69 Goldman, George and Aya Ogishi, "The Economic Impact of Solid Waste Disposal and Diversion in California." Paper presented at the Western Agricultural Economic Association Meeting, Logan Utah, July 20, 2001, p. 14. <http://are.berkeley.edu/extension/EconImpWaste.pdf>.
- 70 Skumatz, Lisa, Jeffrey Morris et al. "Recycle 2000: Recommendations for Increasing Recycling in the Commonwealth of Massachusetts" prepared for the Commonwealth of Massachusetts Executive Office of Environmental Affairs (EOEA) by the Recycling 2000 Task Force, February 1999. p. 6-7
- 71 Personal communication with architect John Boecker, L. Robert Kimball & Associates, November 2005. Also see: Doll, Wesley "Green Design Experiences: A Case Study" PhD Dissertation for University of Pennsylvania, 2005. The thesis evaluated the impacts on students of the Clearview green school compared to the prior, conventional school.
- 72 Data provided by Hashem Akbari Lawrence Berkeley National Laboratory. See: <http://eetd.lbl.gov/heatisland/> See also: PG&E. "High Albedo (Cool) Roofs: Codes and Standards Enhancement Study," 2000. <http://www.newbuildings.org/downloads/codes/CoolRoof.pdf>
- 73 Kats, Greg et al. "The Costs and Financial Benefits of Green Buildings: A Report to California's Sustainability Task Force." October 2003. [www.cap-e.com](http://www.cap-e.com)
- 74 Personal communication with architect Heinz Rudolph, Boora Architects, October 2005.
- 75 See: [http://www.mtpc.org/dg/benefits/2005-12\\_NYSERDA\\_EEA\\_DG-Power-Quality.pdf#search=%22NYSERDA%20EEA%20DG%20power%20quality%22](http://www.mtpc.org/dg/benefits/2005-12_NYSERDA_EEA_DG-Power-Quality.pdf#search=%22NYSERDA%20EEA%20DG%20power%20quality%22)
- 76 Division of Energy Resources, Summer 2004, "An Annual Report to the Great and General Court on the Status of Energy Efficiency activities in Massachusetts for the year 2002" Available at: [http://www.mass.gov/doer/pub\\_info/ee02-long.pdf](http://www.mass.gov/doer/pub_info/ee02-long.pdf)
- 77 Lennon, Mark et al. *Recycling Construction and Demolition Wastes: A Guide for Architects and Contractors*, April 2005. The Institution Recycling Network. Page 3. <http://www.wastemiser.com/CDRecyclingGuide.pdf>
- 78 Kats, Greg et al. "The Costs and Financial Benefits of Green Buildings: A Report to California's Sustainability Task Force." October 2003. [www.cap-e.com](http://www.cap-e.com)
- 79 Freyman, Vance. "Making plans: a New England Contractor conducts careful planning for its construction materials recycling program - Construction Recycling Trends," *Construction & Demolition Recycling*, Jan-Feb 2004. Available at: [www.findarticles.com](http://www.findarticles.com)
- 80 US Environmental Protection Agency Municipal and Industrial Solid Waste Division, Office of Solid Waste. "Characterization of Building-related Construction and Demolition Debris in the United States." June 1998. p. 2-11, Table 8
- 81 Skumatz, Lisa, Jeffrey Morris et al. "Recycle 2000: Recommendations for Increasing Recycling in the Commonwealth of Massachusetts" prepared for the Commonwealth of Massachusetts Executive Office of Environmental Affairs (EOEA) by the Recycling 2000 Task Force, February 1999
- 82 California State and Consumer Services Agency and Sustainable Building Task Force. "Building Better Buildings: A Blueprint for Sustainable State Facilities." December 2001. p16
- 83 Smith, Ray. "Mold Problems Grow in Shops, Hotels, Offices," *Wall Street Journal*, December 4, 2002. [http://www.iuoe.org/cm/iaq\\_bpconc.asp?Item=356](http://www.iuoe.org/cm/iaq_bpconc.asp?Item=356).
- 84 See: [http://www.lemoyne.edu/academics/zogby\\_fall05.htm](http://www.lemoyne.edu/academics/zogby_fall05.htm). See also Kats, Greg "The costs and benefits of green buildings" in *Green Office Buildings A Practical Guide to Development*, Urban Land Institute, 2005.
- 85 Personal communication, Mike Saxenian, November 2005. The National Wildlife Federation has developed a schoolyards habitat program to help schools use school grounds as a teaching resource about nature. See: [www.nwf.org/schoolyard](http://www.nwf.org/schoolyard).
- 86 John Boecker, L. Robert Kimball and Associates, A/E Firm for the Pennsylvania Department of the Environment Cambria Office Building, Ebensburg, PA, the PA Department of Environmental Protection Southeast Regional Office, Norristown, PA. See: [http://www.lrkimball.com/Architecture%20and%20Engineering/ae\\_experience\\_green.htm](http://www.lrkimball.com/Architecture%20and%20Engineering/ae_experience_green.htm)
- 87 Data provided by Heinz Rudolf, BOORA Architects. See Portfolio/Schools at: <http://www.boora.com/> Also see Kats, Greg et al. "The Costs and Financial Benefits of Green Buildings: A Report to California's Sustainability Task Force." October 2003
- 88 Personal Communication with Lucia Athens, Seattle Green Building Program, November 2002. See: <http://www.cityofseattle.net/light/conservesustainability/>.
- 89 "2005 Survey of Green Buildings," Turner Construction. Available at: <http://www.turnerconstruction.com/greenbuildings>



**Sidwell Friends School**  
Architect: KieranTimberlake  
Photo: Peter Aaron /Esto

“USGBC is proud to be a sponsor of this important national analysis of the costs and benefits of greening our nation’s schools. The report’s conclusions provide confirmation of USGBC’s position that by building green we all profit. For our nation’s students this is particularly true. Children’s health is disproportionately affected by indoor pollutants, while light and air quality affects their capacity to learn and succeed. This report shows that we owe it to our children - and ourselves - to make all our schools green.”

— S. Richard Fedrizzi, CEO and Founding Chair, U.S. Green Building Council

“This report makes the business case for greening America’s schools, and it makes a compelling case indeed. But there is also a public health case to be made. Better indoor air quality, lower levels of chemical emissions, generous provision of natural daylighting, better humidity control--these and other features of green schools offer not only environmental and fiscal benefits, but health benefits as well. These health benefits, in turn, manifest in lower student and staff absenteeism, lower staff turnover, lower health care costs, and improved school and job performance. For the more than 50 million students and the more than 5 million teachers and staff who spend their days in schools, these benefits are substantial and precious. Health professionals, educators, parents, and policymakers should carefully consider the conclusions of this report, and do their part to support environmentally friendly, healthy, and sustainable schools.”

— Howard Frumkin, M.D., Dr.P.H., Director, National Center for Environmental Health and Agency for Toxic Substances and Disease Registry, U.S. Centers for Disease Control and Prevention. Senior Editor, *Safe and Healthy School Environments* (Oxford University Press, 2006).

“The choices we make in new construction have huge implications for the health of students, faculty and staff. Unfortunately, too many of America’s 55 million elementary through high school students attend schools that are unhealthy and unsound, and inhibit rather than foster learning. This important study persuasively demonstrates that it costs little more to build high performance, healthy schools and that there are enormous financial, educational and social benefits to students, schools and society at large.”

— Edward J. McElroy, President, American Federation of Teachers, AFL-CIO

## **Green Schools: Attributes for Health and Learning**

### **National Research Council**

The National Research Council National Academy of Sciences expert panel compiled the following recommendation to ensure conventional green buildings were also healthy places for children and adults.

#### **Building Attributes that Support Health and Development:**

- Dryness
- Good indoor air quality and thermal comfort
- Quietness
- Well-maintained systems
- Cleanliness

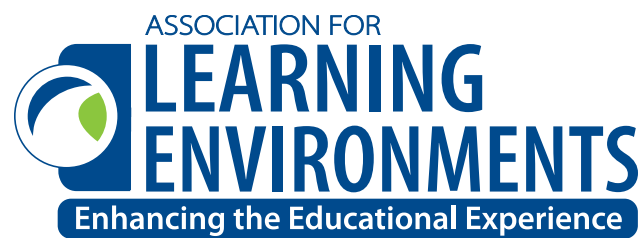
#### **Recommendations:**

- Emphasize the interrelationship among building systems and ensure systems are properly maintained.
- Control excess moisture, dampness, and mold to protect the health of children and school employees, as well as the building's structural integrity.
- Ensure ventilation rates meet current ASHRAE standards and create systems that can be easily adapted to meet new standards for ventilation.
- Emphasize the importance of appropriate operation and preventive maintenance practices for ventilation systems.
- Ensure lighting systems are installed and used based on task, room configurations, layout, and surface finishes.
- Make sure rooms that use daylight address control systems and use blinds or other window treatments to control excessive sunlight or glare.
- Locate schools away from areas of high outdoor noise (i.e. roads, airports, railroads).
- Regularly clean commonly touched surfaces.
- For new schools, ensure the commissioning process begins in the planning stages and continues through occupancy.

National Research Council. Green Schools: Attributes for Health and Learning. National Academy of Science: Washington, DC, 2006.



Prepared by Healthy Schools Network, Inc.



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