

Indoor Air Quality in High Performance Schools

- How Does Indoor Air Quality Impact Student Health and Academic Performance?
 - Key Questions and Answers about High Performance Schools
 - The Issues Facing Schools Today Include:
 - How Will High Performance Schools Help Educate Students?
 - Is High Performance Design Cost Effective?
 - Do I Have to Choose Between Housing More Students and High Performance?
 - Will I Have the Time to Do This?
 - Do I Need to be an Expert in High Performance Building Design?
 - Will High Performance Schools Demand Extensive Maintenance?
 - Benefits of a High Performance School
 - Characteristics of a High Performance School
 - Financing High Performance Schools
 - Life-Cycle Costing
 - Reduced Operating Expenses
 - Increased Funds
 - Financial Incentive and Technical Assistance Programs
 - Avoided Costs and Reduced Litigation Risk
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How Does Indoor Air Quality Impact Student Health and Academic Performance?

Resources for Presentation



Slideshow Presentation: How Does Indoor Air Quality Impact Student Health and Academic Performance

Recent research suggests that a school's physical environment also can play a major role in academic performance.

- Leaky roofs
- Problems with heating, ventilation and air conditioning systems, known as HVAC systems
- Insufficient cleaning or excessive use of cleaning chemical

Other maintenance issues can trigger a host of health problems — including asthma and allergies — that increase absenteeism and reduce academic performance. Research links key environmental factors to health outcomes and students' ability to perform. Improvements in school environmental quality can enhance academic performance, as well as teacher and staff productivity and retention.

- To learn more, read the Quick Reference Guide for Student Health and Academic Performance.

Academic Performance

The measure of school quality and school districts are always looking for ways to improve their performance. They focus on:

- Curricula
- Class size
- Teacher proficiency
- Social-emotional environment
- Nutrition
- Availability of academic and health resources and technologies

Academic Performance Index

A metric that is frequently calculated based on standardized test scores. Factors such as attendance and graduation rates may be considered as well. Factors included for measurement vary by state.

Read About

- The latest scientific data on indoor environmental quality, health and academic performance
- Examples of school districts that have successfully coordinated and integrated IAQ maintenance and health programs to provide evidence from the field
- Recommendations on what you can do to help you move forward towards a better indoor environment for your school

Key Questions and Answers about High Performance Schools

High performance schools are facilities that improve the learning environment while saving energy, resources and money. The key is understanding the lifetime value of high performance schools and effectively managing priorities, time and budget during the design and construction process.

"High performance school" refers to the physical facility — the school building and its grounds. Good teachers and motivated students can overcome inadequate facilities and perform at a high level almost anywhere, but a well-designed facility can truly enhance performance and make education a more enjoyable and rewarding experience. Creating a high performance school is not difficult, but it requires an integrated, "whole building" approach to the design process. Key systems and technologies must be considered together, from the beginning of the design process and optimized based on their combined impact on the comfort and productivity of students and teachers.

The Issues Facing Schools Today Include:

How Will High Performance Schools Help Educate Students?

High performance design can have a positive effect on health and comfort and design strategies such as daylighting have been shown to enhance student learning. Good indoor air quality is essential for teacher and student health. Good design also produces more comfortable environments with proper lighting, air temperature, humidity and noise levels. This reduces distractions and creates environments where students and teachers can see clearly, hear accurately and not feel too warm or too cold.

Is High Performance Design Cost Effective?

Yes. High performance design creates environments that are energy and resource efficient. These increased efficiencies save money on utility bills and are so valuable that some organizations will provide building owners with funds to have them included in the design. Furthermore, healthier environments can bring money *into* the school by lowering absenteeism and increasing funding based on Average Daily Attendance (ADA). These financial, health and productivity benefits are the result of integrated design (i.e., understanding how building elements affect one another to optimize the performance of the entire school).

Do I Have to Choose Between Housing More Students and High Performance?

No. The key is to identify goals and budgets in advance and to verify that the designers and contractors explicitly understand your needs and their responsibilities. School construction budgets are tight, but cost-effective solutions can be found for nearly any budget.

Will I Have the Time to Do This?

Yes. School design and construction timelines are short, but better design does not have to be a roadblock. As a district, you must identify your educational and high performance goals early and communicate them clearly with the design team. Your goals can then be integrated into the design from an early stage and not require time- and money-intensive changes later in the process.

Do I Need to be an Expert in High Performance Building Design?

No. It's the architect's and engineer's role to make sure the design is as effective as possible. You must, however, identify and prioritize your goals and hire designers with the appropriate skill sets. Without the luxuries of expansive timelines and budgets, every school design becomes a balanced system of trade-offs. Understanding the value of high performance design will be important as choices arise.

Will High Performance Schools Demand Extensive Maintenance?

No. They do not require any more maintenance than traditional designs. High performance design does not imply using overly complicated, maintenance intensive systems. It is a design philosophy that integrates the following elements to create the best facility for your budget:

- daylight
- electric lighting
- air conditioning and ventilation systems
- site planning
- materials and controls

All schools, from traditional to high performance buildings, require regular maintenance to ensure they perform as designed. Health, comfort and efficiency can all be compromised without adequate maintenance.

Collaborative of High Performance Schools 2006 Best Practices Manual

Appendix A of the Collaborative of High Performance Schools, 2006 edition, Best Practices Manual, Volume 1 contains four case studies: Alder Creek Middle School, Georgina Blach Intermediate School, Cahuenga New Elementary School and Cesar Chavez Education Center.

- Download the PDF file of Volume 1 of the Best Practices Manual [Exit](#) .
 - You can see all of the CHPS resources at the Collaborative for High Performance Schools website [Exit](#) .
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Benefits of a High Performance School

High performance schools have advantages from the local classroom to the district office, including:

1. **Higher Test Scores.** A growing number of studies are confirming the relationship between a school's physical condition, especially its lighting and indoor air quality and student performance. One recent study of school districts in California, Washington and Colorado indicates a strong correlation between increased day lighting and improved student performance. In the California district, for example, students in classrooms with the most day lighting progressed 20% faster on math tests and 26% faster on reading tests in one year than those in classrooms with the least amount of daylight. This study confirms what teachers, students and parents have known anecdotally for years: learning will be enhanced and test results may improve with a better facility — one with appropriate:
 - acoustics
 - lighting
 - indoor air quality
 - other high performance features
2. **Increased Average Daily Attendance (ADA).** A high performance school provides superior indoor air quality by controlling sources of contaminants, providing adequate ventilation and preventing moisture accumulation. These tactics are designed to:
 - reduce sources of health problems
 - inhibit the spread of airborne infections
 - help keep pollutants, stale air and mold growth out of the classroom

The result will be fewer sick days for students and teachers, especially those suffering from asthma or other respiratory problems. The majority of a school's operating budget is directly dependent on ADA, so even a small increase can significantly boost the operating budget.

3. **Reduced Operating Costs.** High performance schools are specifically designed — using life-cycle cost methods — to minimize the long-term costs of facility ownership. By using less energy and water than standard schools, overall operating costs are lower — particularly helpful in times of rising and uncertain energy prices — and with good operation and maintenance will remain so for the life of the facility. School districts can save 20-40% on annual utility costs for new schools and 20-30% for

renovated schools by applying high performance design concepts. Savings can be used to supplement other budgets, such as:

- maintenance
 - computers
 - books
 - special education
 - classrooms
 - salaries
4. **Increased Teacher Satisfaction and Retention.** High performance classrooms are designed to be pleasant and effective places to work. Visual and thermal comfort is high, acoustics are good and the indoor air is fresh and clean. Such environments become positive factors in recruiting and retaining teachers and in improving their overall satisfaction with their work.
 5. **Reduced Liability Exposure.** Because they are healthy and emphasize superior indoor environmental quality, high performance school buildings reduce a district's exposure to health-related problems, lawsuits and loss of credibility. Remediation expenses for schools with indoor environment problems often reach a quarter of a million dollars and legal costs can be much higher. Consequently, proactive measures that prevent problems are good investments.
 6. **Reduced Environmental Impacts.** High performance school buildings are consciously designed to have low environmental impact. They are energy and water efficient. They use durable, non-toxic materials that are high in recycled content and the buildings themselves can be recycled. They preserve pristine natural areas on their sites and restore damaged ones. And they use non-polluting, renewable energy to the greatest extent possible.

These benefits can only be achieved when districts establish high performance as a specific design goal from the very beginning and fight for it over the course of the development process. A focus on student and teacher performance, coupled with a concern for the environment and a commitment to cost effectiveness, will help ensure that the effort is successful and that any school — no matter what its budget — achieves the highest performance level possible for its particular circumstances.

Characteristics of a High Performance School

A high performance school is:

1. **Healthy.** Good indoor air quality is essential. It requires minimizing pollutant sources and providing adequate ventilation and air filtration. The significant amount of time that students and teachers spend inside schools during their educational career, combined with children's increased susceptibility to indoor pollutants, underscores the importance of high indoor environmental quality.
2. **Thermally, visually and acoustically comfortable.** Thermal comfort means that teachers, students and administrators should be neither hot nor cold as they teach, learn and work. Visual comfort means that quality

lighting makes visual tasks, such as reading and following classroom presentations, easier. The lighting for each room is "designed," not simply specified. Daylight and electric lights are integrated and glare is minimized. Visual comfort also means providing a connection to the outdoors and visual stimulation through the use of windows at eye level to offer views. Acoustic comfort means teachers and students can hear one another easily. Noisy ventilation systems are eliminated and the design minimizes the amount of disruptive outdoor and indoor noise affecting the classroom.

3. **Energy efficient.** Energy-efficient schools save money while conserving non-renewable energy resources and reducing atmospheric emissions of pollutants and greenhouse gases. Heating, ventilating and air-conditioning (HVAC) systems use high efficiency equipment; are "right sized" for the estimated demands of the facility; and include controls that optimize system performance. The school's lighting system uses high efficiency products; optimizes the number of light fixtures in each room; incorporates control devices that ensure peak system performance; and successfully integrates electric lighting and daylighting strategies. The schools are as energy efficient as cost effectively possible. To minimize the use of the HVAC systems, the building shell integrates and optimizes:
 - walls
 - floors
 - roofs
 - windows
 - insulation levels
 - glazing
 - shading
 - thermal mass
 - air leakage
 - light-colored exterior surfaces
4. **Material efficient.** To the maximum extent possible, the school incorporates building materials that have been recycled or produced in a way that conserves raw materials. Such materials may be manufactured with a rapidly renewable resource or recycled content, are durable, or can be recycled or reused. In addition, the school has been designed and built in a manner that reduces waste and keeps re-usable or recyclable materials out of the landfill.
5. **Water efficient.** High performance schools are designed to use water efficiently, saving money while reducing the depletion of aquifers and river systems and minimizing the use of sewage treatment systems. The school uses as little off-site water as possible to meet its needs, controls and reduces water runoff from its site and consumes fresh water as efficiently as possible.
6. **Easy to maintain and operate.** Building systems are simple and easy to use and maintain. Teachers have control over the temperature, airflow, acoustics and lighting in their classrooms and are trained how to most effectively use them.
7. **Commissioned.** The school operates the way it was designed and meets the district's needs. This happens through a formal commissioning process—a form of "systems check" for the facility. The process tests, verifies and fine-tunes the performance of key building systems so that they perform at the

highest levels of efficiency and comfort and then trains the staff to properly operate and maintain the systems.

8. **An environmentally responsive site.** The site is recognized as an essential element of the school building's high performance features. To the greatest extent possible, the school's site conserves existing natural areas and restores damaged ones, minimizes storm water runoff and controls erosion and incorporates products and techniques that do not introduce pollutants or degradation to the project site or at the site of extraction, harvest, or production.
 9. **A teaching tool.** By incorporating important concepts such as energy, water and material efficiency, schools can become tools to illustrate a wide spectrum of scientific, mathematical and social issues. HVAC and lighting equipment and controls systems can be used to illustrate lessons on energy use and conservation and day-lighting systems can help students understand the daily and yearly movements of the sun.
 10. **Safe and secure.** High performance does not compromise safety. Students and teachers feel safe anywhere in the building or on the grounds. A secure environment is created primarily by design: opportunities for natural surveillance are optimized; a sense of community is reinforced; and access is controlled. Security technology is used to enhance, rather than substitute for, the design features.
 11. **A community resource.** The most successful schools have a high level of parent and community involvement. This involvement can be enhanced if schools are designed for neighborhood meetings and other community functions.
 12. **Stimulating architecture.** High performance schools should invoke a sense of pride and be considered a genuine asset for the community.
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Financing High Performance Schools (The California Experience)

High performance schools are cost effective for a number of reasons. For example, they can:

- Bring more money to the school by increasing average daily attendance
- Keep more money in the school by significantly reducing utility bills
- Take advantage of currently available incentive programs

When the avoided costs of workers' compensation claims and litigation are also considered, high performance schools become an even wiser business choice for school districts. Discussed below are issues related to financing high performance schools, include:

Life-Cycle Costing

School facilities are investments. State government and local communities spend billions of dollars per year on new facilities for current and future generations of students. Unfortunately, the institutional separation of operational and construction budgets can create schools that are economically, environmentally and educationally poor investments. Many high performance measures can be incorporated into a school design without increasing first costs, but additional investments can increase the health and efficiency of the school even further. However, if a conventional financing methodology is used, design measures that save money in the long-term may be rejected due to a greater initial cost.

Life cycle costing is a means to calculate and compare different designs to identify which is the best investment. Districts can use it to assess the total cost of ownership for a facility over time. All of the building expenses that can be calculated are included in the analysis; including initial costs (design and construction), operating costs (energy, water, other utilities and personnel) and maintenance, repair and replacement costs. The values are adjusted for the time-value of money to represent the true value of the investment. Predicted costs for alternative design approaches can then be compared, allowing the district to select the design that provides the lowest overall cost of ownership consistent with the desired quality level.

The true cost of a school includes much more than the cost to design and build it. The long-term costs of operating and maintaining the facility must also be included. Only by evaluating all three of these factors can a community understand how much a new school really "costs". And only by looking at all three factors simultaneously can the impacts of specific design approaches, especially those that result in better long-term performance, be evaluated.

High performance windows, for example, may cost more upfront but may result in energy savings that pay for the extra costs in a few years and then continue to save money for the school for years to come. Life cycle cost analysis is the key to making these kinds of comparisons and to creating new schools with the lowest long-term costs of ownership. Note, however, that life cycle costing will only address some of the benefits of high performance design. Many benefits, such as improved health and test scores, are valuable, but difficult to quantify monetarily.

Reduced Operating Expenses

High performance schools cost less to operate. School districts spend less for:

- electricity
- gas
- water
- maintenance
- other ongoing facility operating costs

This allows more money to be spent for salaries, books, teaching supplies and other items with a more direct link to the true mission of schools: educating students.

How much savings can be expected? School districts can save 30-40 percent on annual utility costs for new schools and 20-30 percent for renovated schools by applying high performance design and sustainability concepts. The potential for savings is greater in new schools because it's possible to "design out" inefficiencies from the outset, thereby saving money year after year.

The California Energy Commission estimates that the average cost of energy is \$126 per student. Expenditures for electricity and natural gas typically run 2.2% to 2.7% of the total schools budget. High performance design solutions could yield savings of up to \$50 per year per student with aggressive designs. Furthermore, these savings continue to reap savings as long as they are used as designed. Integrated design is the key to savings of this magnitude. From the beginning of the design process, each of the building elements (windows, walls, building materials, air-conditioning, landscaping, etc) is considered part of an integrated system of interacting components. Choices in one area often affect other building systems; integrated design leverages these interactions to maximize the overall building performance.

Increased Funds

Investing in high performance measures can bring monetary returns to the school district. District funds come from a variety of state, federal and local sources and every district has a unique blend of sources. In general, a district's funding can be divided into three components:

- **General Purpose Funds** are calculated by multiplying a school's Average Daily Attendance by its Revenue Limit. Current revenue limits for the 2000-2001 school year are \$4,306, \$5,175 and \$4,485 for elementary, high school and unified schools, respectively.
- **Categorical Aid** covers a wide array of programs from special education to instructional materials. The application process and funding amounts vary depending on the programs. Depending on the district, categorical aid can range from small amounts to almost one-third of their total budget.
- **Miscellaneous funds** comprise the small remaining amount. Typical sources are the lottery and various local sources.

High performance schools can increase school funding by increasing average daily attendance, through reduced illnesses and more user satisfaction. Because the revenue limits range from \$4,300 to \$5,175, even small changes in attendance can significantly affect a school's bottom line. Recent changes in the funding mechanism that exclude excused absences from the Average Daily Attendance calculation further increase the financial necessity of keeping as many students in class as possible.

For example, assume that a 500-student elementary school invests \$4.00 per square foot on high performance lighting and air-conditioning improvements that will improve the indoor environment quality. Based on the \$4,300 revenue limit, an increase in Average Daily Attendance of 1.75% would pay back all of the investments in only two years. And this doesn't begin to take into effect any utility savings from energy efficiency improvements. Although some studies have

correlated characteristics of the indoor environment to changes in student health, behavior and performance, estimating the degree to which absenteeism might be reduced by a given investment in high performance design is unknown. Ongoing research may eventually provide an answer, but for now it's reasonable to assume that investing in high indoor environmental quality may decrease absenteeism.

Financial Incentive and Technical Assistance Programs

Several programs are currently available to financially and technically assist districts and designers in creating high performance schools.

The **Savings by Design** program promotes energy-efficient design in new construction and renovation projects with financial incentives and technical resources for designers, contractors and building owners. The program is funded by California utility ratepayers and is administered by Pacific Gas and Electric Company, San Diego Gas & Electric, Southern California Edison and Southern California Gas Company under the auspices of the California Public Utilities Commission. It is available for any school district within these utilities' service territories. The financial performance-based incentives increase with the energy efficiency of the design and can be a significant source of additional funds. In addition, Savings by Design offers technical assistance and project-specific design assistance to the school design community. Savings by Design sponsors training and continuing education in integrated school design practice such as:

- day lighting systems
- proper HVAC sizing
- integrating internal loads from other end uses
- proper HVAC installation
- building system modeling

- More information is available at the Savings by Design website & [Exit](#).

The California Energy Commission's **Bright Schools program** offers a full suite of programs to schools considering high performance design strategies in new and existing buildings. School districts can use the program to evaluate potential areas for energy and resource savings and prioritize their needs. The services are typically provided at little or no cost to districts.

On new construction projects, the Bright Schools program provides a variety of services, including:

- design consultation
- cost-effectiveness calculations
- development of specifications
- help in selecting the design team
- review of construction documents
- complete value engineering of specific efficiency measures

Bright Schools also provides comprehensive services for energy renovations. The particular services are determined by the program and the district and may include:

- energy audits
- feasibility studies
- design review
- equipment specifications
- contractor selection
- installation assistance

In addition, schools can take advantage of a loan program to help finance the required district match of renovation projects.

- More information is available at the California Energy Commission website [Exit](#).

Standard Performance Contracting (SPC) is a renovation incentive program funded by utility ratepayers and administered by Pacific Gas and Electric Company, San Diego Gas & Electric and Southern California Edison under the auspices of the California Public Utilities Commission. It offers schools additional financial support for implementing energy efficiency improvements to existing facilities. Under the program, Energy Efficiency Service Providers (EESPs) provide information and energy audit services to analyze energy saving opportunities in existing school buildings.

If energy-efficiency projects are identified, the utility will provide funds to help finance the project in exchange for the energy savings. The utility can make a contract with either the school district or the EESP, depending on how the district wants to manage the project. Often, school districts will contract with an EESP for project development, management and construction and the EESP will contract with the utility. Either way, the school district receives an improved facility at a lower cost.

- For a list of resources, see the National Association of Energy Service Companies (NAESCO) bookstore [Exit](#).

Energy Design Resources, is a program to develop and disseminate design tools and resources that help elevate energy efficiency in new schools to a higher priority. It is funded by utility ratepayers and administered by Pacific Gas and Electric Company, San Diego Gas & Electric and Southern California Edison under the auspices of the California Public Utilities Commission, Resources include both informational publications such as design briefs and in-depth handbooks on the latest energy technologies and software design tools to guide design decision-making.

- All resources are available for download at the Energy Design Resources website [Exit](#).

Avoided Costs and Reduced Litigation Risk

The considerable costs of poor school indoor environmental quality (IEQ) are borne by students, staff, parents and the local community. In the school populations, the costs include poor health, reduced learning effectiveness and increased frustration when IEQ problems become unmanageable. These costs are difficult to quantify. More easily counted are the strained budgets and staff resources expended by districts for facility repairs due to:

- insufficient maintenance
- community relations damage control
- litigation and workers' compensation claims

In addressing such problems, schools must use resources that would otherwise be available for educational and other programs.

Poor school IEQ can cause both short-term (reversible) and long-term (chronic) effects in students and staff. Overcrowded, poorly ventilated classrooms contribute substantially to the spread of infectious diseases, such as colds and influenza. Poorly maintained carpets, dirty air ducts and water-damaged materials are prime breeding grounds for a plethora of substances that can trigger asthma attacks, sensitize allergy-prone individuals and cause sinus and respiratory infections.

Asthma is one of the environmentally triggered diseases acquired during childhood that may be carried well into the adult years. Other chronic diseases include irreversible lung and respiratory illnesses that result from chronic irritation by airborne chemical and/or biological contaminants. The economic costs of these long-term, possibly lifelong, diseases are substantial; the costs in terms of quality of life are more profound and certainly difficult to measure.

One of the ramifications of school building neglect and its consequent adverse effects on IEQ is the potential for litigation from students, parents and staff. Crisis-stage IEQ problems can be extremely costly, may lead to litigation and can be detrimental to long-term relations among:

- school administrators
- staff
- parents
- students
- public agencies

The fiscal, political and social costs of addressing a crisis situation are often larger than anticipated. Schools may close temporarily when a formerly manageable problem becomes a financial, logistic and emotional crisis. Besides the costs of conducting emergency repairs, a school closing requires alternative space and making up missed classes. Reopening schools that have been closed is also a difficult process, due to the logistics of inspections, the uncertainties of authority and residual fears. Workers' compensation claims by school staff are another financial cost to districts when IEQ complaints escalate.

The threat of increasing IEQ problems, recognition of adverse health effects from indoor air exposures and the litigious nature of societal interactions serve as a warning that poor IEQ in California schools can threaten the financial stability of local school districts. A number of lawsuits have been filed against California school districts. For example, after complaints, investigations and legal actions spanning more than three years, a student received a cash settlement for damages from "contaminated air" in his junior high school classroom. At the same time a third of the school staff filed workers' compensation claims for respiratory and other health problems.

In other states, lawsuits have been settled for millions of dollars. In a school district in Washington, D.C., leaky school roofs and other IEQ problems prompted a judge to order closed 21 school buildings due to the resultant potential fire hazard. For each incident that makes the evening news or is adjudicated in court, there are many less publicized cases occurring in other districts. Building a high performance school helps protect districts from IEQ problems by designing out potential problems and verifying and documenting the facility's health.

(The material presented here is adapted, with permission, from the Collaborative for High Performance Schools "Best Practices Manual".)

- The 2006 version of the manual is available for downloading and ordering at the Collaborative for High Performance Schools website [Exit](#) .)
- See also the Energy.Gov - Commercial Buildings Integration website.

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