Volume I
High Performance Schools
Best Practices Manual
2006 Edition
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Preface

This is a unique period in California history. The state, already educating one out of every eight students in America, has seen historical enrollment rates four times higher than national averages. Hundreds of schools a year are being built to house the influx of new students moving into the system. The California Department of Education predicts that there will be more than 900,000 students without a classroom through the year 2009. At the same time, school facility infrastructure across the state is aging—the Department of Education predicts more than 1.2 million California students are in classrooms that are more than 25 years old, with almost 50,000 of the classrooms scheduled for modernization between now and 2009.

Real estate and energy prices also add to the challenges specifically facing California school districts. The Los Angeles Unified School District, among other agencies, have reported paying double and triple their estimates for land when projects were proposed years ago. And California schools are spending nearly $700 million per year on energy in a time of rising concern over energy supplies and tight school budgets. These figures illustrate an enormous opportunity for our state’s school districts to build the next generation of school facilities that improve the learning environment while saving energy, resources, and money.

The goal of the Collaborative for High Performance Schools (CHPS) is to create a new generation of high performance school facilities in California. The focus is on public schools and levels K-12, although many of the recommended design principles apply to private schools and higher education facilities as well. High performance schools are healthy, comfortable, energy efficient, resource efficient, water efficient, safe, secure, adaptable, and easy to operate and maintain. They help school districts achieve higher test scores, retain quality teachers and staff, reduce operating cost, increase average daily attendance, and reduce liability, while at the same time being friendly to the environment.

2 California Energy Commission
THE CHPS BEST PRACTICES MANUAL

This Best Practices Manual is split into six volumes:

- **Volume I: Planning.** This volume addresses the needs of school districts, including superintendents, parents, teachers, school board members, administrators, and those persons in the school district that are responsible for facilities. These may include the assistant superintendent for facilities (in large districts), buildings and grounds committees, energy managers, and new construction project managers. Volume I describes why high performance schools are important, what components are involved in their design, and how to navigate the design and construction process to ensure that they are built.

- **Volume II: Design Guidelines.** This volume contains design guidelines for high performance schools. These are tailored for California climates and are written for the architects and engineers who are responsible for designing schools as well as the project managers who work with the design teams. Organized by design discipline, the guidelines present effective strategies for the design of schools that meet the CHPS high performance school criteria.

- **Volume III: Criteria.** The CHPS criteria are a flexible yardstick that precisely defines a high performance school. School districts are encouraged to adopt the criteria for their new buildings and major modernizations.

- **Volume IV: Maintenance and Operations.** This volume presents high performance guidelines for the maintenance and operation of schools. Information in this volume will help ensure that high performance school buildings continue to operate as their designers intended, providing optimal health, efficiency, and sustainability.

- **Volume V: Commissioning.** This volume provides important information on commissioning high performance schools—a critical step in ensuring that the technologies and high performance elements are actually built and tested to meet specifications.

- **Volume VI: High Performance Relocatable Classrooms.** This volume provides a guide to the CHPS specification for high performance relocatable classrooms. Related issues such as placement on the site, applicable codes and the procurement process are covered to ensure that all new relocatable classrooms are efficient and good learning environments.

The Best Practices Manual is supported by the Collaborative for High Performance Schools' Web site (www.chps.net/) which contains research papers, support documents, databases and other information that support the manual.
THE COLLABORATIVE FOR HIGH PERFORMANCE SCHOOLS

CHPS was formed in November 1999, when the California Energy Commission called together Pacific Gas and Electric Company, San Diego Gas and Electric, and Southern California Edison to discuss the best way to improve the performance of California’s schools. Out of this initial partnership, CHPS grew to include a diverse range of government, utility, and non-profit organizations with a unifying goal to improve the quality of education for California’s children. In early 2002, CHPS incorporated as a non-profit organization, further solidifying its commitment to environmentally sound design that enhances the educational environment for all schoolchildren.

ACKNOWLEDGEMENTS

A great number of people have contributed to the development of the Best Practices Manual Volume I and this 2006 update. Charles Eley is the executive director of CHPS, Inc. and served as the technical editor.

For this 2006 edition, the CHPS Best Practices Manual 2006 Volume I update review team contributed many hours reviewing the document and providing valuable direction and input. The review team included:

- GreenBank: Alice Sung
- CA Department of Education: Diane Waters
- CA Division of the State Architect: Panama Bartholomy
- CA Integrated Waste Management Board: Bill Orr, Clark Williams, and Dana Papke
- CA Office of Public School Construction: Karen Mandell
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- Architectural Energy Corporation: Kyra Epstein, David Goldman, Erik Kolderup, Camren Cordell, Aditi Raychoudhury, Zelaikha Akram, Anamika, Kimberly Got, Randy Karels, and Joe Kastner,
- Southern California Edison: Deborah Weintraub and Tony Pierce (Adapted from *Mainstreaming the Sustainably Designed School*)
- Wendel, Rosen, Black & Dean: Donald Simon (construction contracts)

Finally, the current and past CHPS Board of Directors deserves special acknowledgement for their continued guidance and support. Current chair Jackalyne Pfannenstiel (California Energy Commission) and past chairs Steve Castellanos (State Architect) and Robert Pernell (California Energy Commission) provided exceptional leadership and directions. Current board members include: Gregg Ander (Southern California Edison), Jessica Mack (Southern California Gas), Chip Fox (San Diego Gas & Electric), Jim Barnett (Sacramento Municipal Utility District), John Palmer (San Juan Unified School District), Brian
Dougherty (Dougherty + Dougherty), Bill Orr (California Integrated Waste Management Board) and Oliver Kesting (Pacific Gas and Electric). The current Advisory Board includes: Kathleen Moore (California Department of Education) and Karen Mandell (Office of Public School Construction). Past board and advisory board members include Randall Higa (Southern California Gas), Chuck Angyal (San Diego Gas and Electric), Duwayne Brooks (California Department of Education), and Grant Duhon (Pacific Gas & Electric).
High Performance Schools

OVERVIEW

High performance schools are facilities that improve the learning environment while saving energy, resources, and money.

So, what's the catch? Aren’t these designs prohibitively expensive and time consuming to design? The short answer is no; the key lies in understanding the lifetime value of high performance schools, hiring skilled designers, and effectively managing priorities during the design and construction process. The detailed answer is woven throughout this manual and addresses these important issues facing schools today:

- **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. These factors reduce distractions and create 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. These financial, health, and productivity benefits are the result of integrated design: understanding how building elements affect one another to optimize the performance of the entire school.
High Performance Schools

Benefits

- **Do I have to choose between housing more students and high performance?** No. Because a school facility must be able to house as many students as possible, building high performance schools at the expense of fewer classrooms is not an option. 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 and have the skills to deliver what you want. 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 school district, you must identify your educational and high performance goals early and communicate them clearly with the design team. Integrate your goals into the design from an early stage and implement commissioning to reduce time- and money-intensive changes later in the process. The CHPS Criteria (Volume III) is a convenient and flexible system for identifying your high performance goals. A pre-design goal setting meeting (sometimes referred to as a “charrette”) with all of the stakeholders, using the CHPS Criteria as a guide, can aid this effort.

- **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 luxury 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 daylight, electric lighting, air conditioning and ventilation systems, site planning, materials, and controls to create the best facility for your budget. 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.

**BENEFITS**

High performance school benefits are achievable only 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.

**Benefits of a High Performance School**

- Higher student test scores
- Reduced operating costs
- Increased daily attendance
- Enhanced teacher performance and satisfaction
- Reduced environmental impact
- Increased building life
- Reduced liability.
possible for its particular circumstances.

**Higher Student Test Scores**

Learning is a dynamic, complicated process that can, and does, occur in all types of buildings and settings. Anecdotally, the argument linking increased student performance with high-quality school facilities is straightforward. Students in classrooms that are quiet, well-lit, and properly ventilated with healthy air will learn faster because they are more comfortable, are sick less often, can see and hear better, and are less distracted. Poor lighting, poor acoustics, and poor indoor air quality are barriers to education. High performance schools remove these barriers, allowing teachers and students to work under the best possible conditions.

Quantifying the influence of school facilities on learning is a longstanding and highly debated subject in the educational community. Research studies are complicated by the highly systemic nature of education, and the range of social, pedagogical, psychological, and environmental variables involved. However, a growing number of studies are confirming the relationship between a school’s physical condition—especially its lighting, acoustics, and indoor air quality—and student performance.

Mark Schneider’s paper, “Do School Facilities Affect Academic Outcomes?” provides an excellent literature review of the connections between school facilities and educational outcomes. It is available from the www.edfacilities.org Web site. This paper looks comprehensively at lighting, acoustics, building age, quality and aesthetics, school size, and class size. The bibliography is extensive and provides a good source for additional reading.

Among the environmental factors that affect learning, it is well known that light has profound effects, and recent research directly links daylighting to increased learning. The following are three powerful studies.

- The most compelling study examined school districts in California, Washington, and Colorado. It shows a strong correlation between increased daylighting and improved student performance. In the California study, for example, students in classrooms with the most daylighting progressed 20%
faster on math tests and 26% faster on reading tests as compared to students in classrooms with the least amount of daylight. See the sidebar on the following page for details.

- After a year of detailed observation of the behavior, hormone levels, and health of 90 eight-year-old students, researchers in Sweden\(^4\) found significant correlations between these factors and daylight levels. The students were split among four classrooms with different types of natural and artificial light. Their results indicated that “work in classrooms without daylight may upset the basic hormone pattern, and this in turn may influence the children’s ability to concentrate or cooperate, and also eventually have an impact on annual body growth and sick leave.”

- Researchers examining the effect of daylight in three North Carolina schools found correlations between daylight and increased performance.\(^5\) The study reports positive results for children moving to daylighted schools: student performance increased up to 14%.

Indoor air quality can also be linked to student performance. Because of the complexities of indoor chemistry and the wide variety of sources of indoor pollutants, no study has yet directly tied differences in indoor air quality to student performance. However, a recent report from Lawrence Berkeley National Laboratories (LBNL)\(^6\) summarized the history of school investigations initiated by health symptoms and/or environmental complaints. They reviewed 53 Health Hazard Evaluation Reports from 1981 through 1994 from the National Institute for Occupational Safety and Health (NIOSH), and 35 California indoor air quality investigations for the 1988–1996 period. They found that the frequency of recurring symptoms, such as headaches, fatigue, memory problems, eye irritation and cough, in schools where there had been complaints was markedly increased relative to schools without complaints. Similar symptoms in office buildings have been associated with reduced worker productivity, suggesting that school indoor air quality problems can be severe and persistent enough to affect the learning ability of students individually or as a group.

The message is clear, and it confirms what teachers, students, and parents have known anecdotally for years: a better facility—one with appropriate acoustics, lighting, indoor air quality, and other high performance features—will enhance learning and can improve standardized test score results.

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A Closer Look — Daylighting and Student Performance

In a 1999 study, the Heschong Mahone Group found a statistically compelling connection between daylighting and student performance. The study isolates daylighting as an illumination source, and separates illumination effects from other qualities associated with daylighting from windows.

Student performance data from three elementary school districts was obtained and correlations investigated between the data and the amount of daylight provided within each student’s classroom environment. Data from second- through fifth-grade students in elementary schools was used because extensive information was available from highly standardized tests administered to these students, and because elementary school students are generally assigned to one teacher in one classroom for the entire school year. Thus, it was reasoned that if the physical environment does indeed have an effect on student performance, such a correlation could be established by looking at the performance of these elementary school students.

The research analyzed test score results for over 21,000 student records from the three districts, located in Orange County, California; Seattle, Washington; and Fort Collins, Colorado. The data sets included information about student demographic characteristics and participation in special school programs. Architectural plans, aerial photographs, and maintenance records were reviewed, and the research team visited a sample of the schools in each district to classify the daylighting conditions in over 2,000 classrooms. Each classroom was assigned a series of codes on a simple zero-to-five scale, indicating the size and tint of its windows, the presence and type of any skylighting, and the overall amount of daylight expected.

The daylighting conditions at California’s Capistrano Unified School District were the most diverse, and the data from that district were also the most detailed. Thus, Capistrano provided the most precise model. In this district, it was possible to study the change in student test scores over a school year. Controlling for about 40 other variables, it was found that students with the most daylighting in their classrooms progressed 20% faster on math tests and 26% faster on reading tests in one year than those with the least daylighting. Similarly, students with the largest window areas were found to progress 15% faster in math and 23% faster in reading than those with the smallest windows. And students that had a well-designed skylight in their room — one that diffused the daylight throughout the room, reduced glare, and allowed teachers to control the amount of daylight entering the room — also improved by 19% to 20% faster than those students without a skylight.

The research team also identified another window-related effect: students in classrooms where windows could be opened for natural ventilation were found to progress 7% to 8% faster than those with fixed windows, regardless of whether the room also had air conditioning. These effects were all observed with 99% statistical certainty.

The studies in Seattle and Fort Collins used the final scores on math and reading tests at the end of the school year, rather than the amount of change from the beginning of the year. In both of these districts, the research also found positive, highly significant effects from the daylighting. Students in classrooms with the most daylighting were found to have 7% to 18% higher scores than those with the least daylighting.

These performance benefits could be caused by a variety of daylighting effects from, including increased visibility due to higher illumination levels and light quality; improved student health, mood, and behavior; reduced effects of daylight deprivation; and higher arousal levels.

The three districts have different curriculum and teaching styles, different school building designs, and very different climates. And yet, the results of studies show consistently positive and significant effects. This consistency persuasively argues that there is a valid and predictable effect of daylighting on student performance.

However, the presence of daylight alone does not necessarily always translate to increased student productivity. Quality is a critically important factor in daylighting design. Classrooms with clear, non-diffused skylights are susceptible to patches of very bright light and glare which can become a detriment to learning. In fact, the Heschong Mahone Group found that students with these types of skylights progressed up to 21% more slowly in reading.
High Performance Schools

Benefits

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—most notably 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, additional classrooms, and salaries.

Increased Average Daily Attendance

Average daily attendance is an important metric because it is one way to illustrate the most important school design issue—protecting student health. Although many factors can influence whether a student comes to school, inadequate facilities can cause and exacerbate physical problems that lead to absenteeism. Consider asthma, for example. Poor indoor air quality triggers asthma attacks in susceptible children. The U.S. Environmental Protection Agency (EPA) states that asthma is the leading cause of school absenteeism due to a chronic illness, accounting for an estimated 1.2 million missed school days per year in California. The American Lung Association states flatly that asthma is the leading cause of school absences.

Although many 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 and appropriate to assume that investing in high indoor environmental quality can improve student health. A high performance school provides superior indoor air quality by controlling sources of contaminants, providing adequate ventilation, and preventing moisture accumulation. These tactics, designed to reduce sources of health problems and inhibit the spread of airborne infections, help keep pollutants, stale air, and mold growth out of the classroom.

Since healthier students and staff will have fewer sick days, less absenteeism has large financial benefits as well: the majority of a school’s operating budget is directly dependent on average daily attendance, so even a small increase can significantly affect district budgets.

Enhanced Teacher Performance and Satisfaction

Many districts are facing teacher shortages and high turnover rates. The educational and financial costs of recruiting and training teachers are significant. High performance classrooms are designed to be pleasant, 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.
Reduced Environmental Impact

High performance school buildings are consciously designed to have low environmental impact. They are energy and water efficient. They use durable, non-toxic materials 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. As a consequence, high performance school buildings are good environmental citizens, and are designed to stay that way for the entire life of the building.

Increased Building Life

Because they are well designed with durable and material-efficient components, commissioned, and well maintained, high performance schools can last longer without significant repair than many traditional schools. Careful design and choice of building materials, as well as an investment in training for maintenance, custodial staff, and teachers and administrators about how high performance schools operate, can save districts much-needed funding from lower operating costs and longer building life.

Reduced Liability

Because they emphasize health and 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.

FEATURES

"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.

Because schools are complicated structures, high performance design covers a broad and diverse range of disciplines and choices. Building a high performance school does not mean buying and installing the latest, most expensive equipment. Rather, it is a design philosophy focused on choices that improve the learning environment and save resources. Some choices are essential and others are discretionary; it's important to keep the range of choices in perspective and focus on the key design issues.

Features of a High Performance School

- Healthy
- Energy, material, and water efficient
- Thermally, visually, and acoustically comfortable
- Easy to maintain and operate
- Commissioned to ensure building performance
- Safe and secure
- Effective as a tool for learning about environmental responsibility
- Architecturally stimulating and flexible for multiple school and community uses
Schools are unique buildings that every day house one-fifth of the population: almost 6 million children and more than 200,000 teachers and support staff. There are few other settings in which 20–30 people occupy such a small space or work on such a wide a range of activities as in a school classroom. Occupant density is approximately four times as great as a typical office building, and schools include many “special use” areas all within the same facility, such as laboratories, art studios, industrial shops, duplication facilities, and gymnasiums.

Creating a high performance school is not difficult, but it requires an integrated, “whole building,” team 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. A high performance school is:

**Healthy**

Indoor air quality has an indirect, yet profound, effect on learning. Inadequate ventilation leads to the buildup of carbon dioxide and other indoor pollutants, which are often associated with discomfort and the inability to concentrate. Exposures to volatile organic compounds (VOCs) and other indoor pollutants can cause a range of acute symptoms at relatively low concentrations; eye and respiratory irritation are the most common complaints. These contaminants can also cause headaches, mental confusion, behavioral problems, and fatigue—all of which diminish students’ ability to concentrate or assimilate information. Among asthmatics, the increased need for medication (often with sedating side effects), exacerbations of asthma attacks, and related absences from school further undermine education in affected classrooms.

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 good indoor air quality.

**Energy, Material, and Water Efficient**

At a high performance school, the site is recognized as an essential element of the school building’s high performance features. To the extent possible, the school’s site existing natural areas and restores damaged ones; minimizes stormwater 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. By taking these issues into consideration, designers can be efficient with their use of energy, materials, and water.

Energy-efficient schools cost less to operate, which means that more money can be used for books, computers, teacher salaries, and other items essential to the educational goals of schools. Energy-efficient schools also reduce emissions to the environment, since energy use is related to emissions of chemicals that contribute to global warming and acid rain. By following the guidelines in this manual, energy use can be reduced by up to 40% compared to conventional buildings that minimally comply with the California’s Energy Efficiency Standards for Residential and Nonresidential Buildings (Title 24).
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.

Water scarcity is a major problem in much of California. 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.

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. 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.

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.

Commissioned to Ensure Building Performance

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.

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.
Effective as a Tool for Teaching about Environmental Responsibility

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. Heating, ventilation, and air conditioning (HVAC) systems; lighting equipment; and controls systems can be used to illustrate lessons on energy use and conservation, and daylighting systems can help students understand the daily and yearly movements of the sun.

Architecturally Stimulating and Flexible for Multiple School and Community Use

High performance schools should invoke a sense of pride and be considered a genuine asset for the community. The most successful schools have a high level of parent and community involvement, sometimes using a “joint use” concept to use buildings for different purposes at different times to share resources and build community. Examples of shared or joint use would be a gym or multi-purpose room that would be designed and built for school meetings and activities during the day and as an adult community center after school hours. Likewise, the library, childcare center, swimming pool, gardens, recreational facilities, and parking lots would also be designed, built, and shared jointly. Once built, the city and school district would jointly maintain, administer, and share in the costs of staffing and maintenance of the commonly used areas.
Adopting and Implementing a CHPS District Resolution

Ideally, support and direction for designing high performance schools comes from a district level. Currently, 15 districts in California have passed resolutions that require all new school construction to comply with CHPS criteria.

This chapter gives a brief “roadmap” for implementing CHPS in your district. Appendix B provides this roadmap in an easy-to-use table format and also includes a monitoring plan.

The Roadmap is based on the experience of school districts that began implementing CHPS as early as 2001. The key finding is that a centralized, school district-designed high performance school program provides the best opportunity to produce schools that consistently meet a district’s sustainable design priorities at the lowest possible cost.
GOAL: Implement CHPS District wide

Evaluate Program

Monitor program effectiveness

Project Delivery

Design activities
Vol II–III

Develop CHPS implementation plan
Vol I–IV

Select and implement CHPS credits
Vol III

Establish CHPS program management

Develop Program

Adopt Policy

Build support for CHPS mandate

Adopt Board resolution

Manage Program

Establish CHPS program management

Operation activities
Vol IV

Post-construction activities

Construction activities
Vol III–IV

Pre-design activities
Vol I

Symbols:

1 – use District Scorecard
2 – Provide Training
Cx – Commission Project
DEVELOP PROGRAM

Adopt Policy

The recommended first step for school districts seeking to implement a high performance schools program is to make a formal commitment to CHPS. This commitment will be most effective when it is supported by all of the key CHPS constituencies. The first recommended steps of a CHPS program, therefore, are to:

- Build the necessary constituency to support CHPS.
- Have the board of education adopt a CHPS resolution. The resolution should require that all new construction, school additions and modernization projects, and maintenance and operation programs, meet CHPS standards.

Build Support for CHPS Mandate

To ensure a successful CHPS program, it is important that all interested constituencies have an opportunity to learn about and support a CHPS initiative. This is best done by identifying and working with the key players inside and outside the district and by clearly articulating to them the rationale for CHPS.

Include Key Internal and External Players

The constituencies that need to support a CHPS program fall into two classifications: school district staff and outside participants. The weight that each of these needs to play in adopting a CHPS resolution will vary with the school district. Some school districts, in fact, have adopted resolutions with minimal participation by internal or external players. It is recommended, however, that school districts collaborate with as many parties as are needed to ensure the long-term success of the program.

School district staff will be responsible for implementing CHPS. A CHPS program will therefore be most effective if the key internal groups support the CHPS resolution before it is adopted. The key internal group should include:

- Facilities management (design, construction, operations and maintenance)
- Environmental health and safety officials
- Bond oversight committee
- Principals and teachers.

Outside groups who may be interested include those impacted by a CHPS mandate and those who can support the initiative with technical and/or financial assistance. Key external groups may include:
Adopting and Implementing a CHPS District Resolution

Develop Program

- Parents
- CHPS representatives
- Local utilities
- Community based organizations (children’s and environmental groups)
- State and Federal agencies (i.e., California Integrated Waste Management Board, California Energy Commission, and EPA).

Use Available Rationale

A school district’s rationale for adopting CHPS is outlined on the CHPS Web site. In this brief presentation, a CHPS representative will provide an overview of the benefits of high performance schools tailored to a district’s needs. The CHPS School Planning Kit is a worthy means of introducing CHPS to district officials.

There are many reasons why school districts should adopt a CHPS mandate. Most importantly, CHPS schools:

- Increase student performance
- Improve student and staff health
- Lower operating costs
- Reduce absenteeism
- Lessen a school’s impact on the environment
- Take greater advantage of incentive programs
- Gain leverage with vendors and suppliers
- Develop and reuse high performance design elements
- Earn CHPS District Resolution credits.

A CHPS resolution also provides clear direction for the facilities department. If a district is already implementing high performance schools, a resolution formalizes and provides structure for this effort. You can download a “Sample District Resolution” at: www.chps.net/chps_schools.

A growing number of California school districts have adopted CHPS resolutions. Adopting a CHPS resolution has become the recognized first key step in implementing a CHPS program.

Adopt District Policies

By adopting a CHPS resolution, the district school board acknowledges that high performance criteria are a priority for school construction. CHPS provides the vehicle to qualify and quantify the program. The criteria function as a flexible yardstick so that each district can pursue the credits that match its priority.
Use CHPS' Model Resolution

CHPS has developed a model resolution that provides the key recommended language. It is available on the CHPS Web site along with resolutions already adopted by California school districts. Key elements include:

- Require that all new construction, school additions, and modernization projects (and perhaps maintenance and operation programs), meet or exceed the CHPS qualifying threshold.
- Establish high performance priorities (according to CHPS Criteria).
- Require the development and presentation to the board of a CHPS implementation plan in a specified timeframe.
- Establish ongoing reporting requirements; for example, quarterly and/or annual reports that include the list of adopted or targeted CHPS credits (including their cost and benefit), CHPS scorecards for individual projects, and the received financial incentives.
- Require that all construction projects participate in Savings By Design (if eligible) and other available design assistance and financial incentive programs.
- Require facilities staff to coordinate the CHPS program with the appropriate local, regional, state, and federal agencies. Examples include water districts, storm water districts, and waste management agencies.

Incorporate Policy into Future Local Facilities Bonds

It is important that school construction bonds incorporate CHPS mandates. The process of issuing a bond typically begins with a needs assessment to determine the building program and budget. The needs assessment should include the costs and benefits of CHPS.

Design Program

To implement a CHPS program, a series of steps has been identified that will help a school district smoothly move from the status quo to a high performance design, construction, and maintenance program. The goal is to institutionalize CHPS to make CHPS an integrated, ongoing part of a district’s facilities development and maintenance program.

Establish CHPS Program Management

The first step in designing a CHPS program is to establish program management.

Appoint CHPS Program Manager

It is important that a high ranking facilities official, such as the director of facilities, be appointed to manage the CHPS program. Facilities management support and direction is imperative for a CHPS program to be successful because implementing CHPS will require changes to standard project design, construction and maintenance practices.
Establish CHPS Committee

A number of facilities-related responsibilities are impacted by a CHPS initiative. Management-level representatives of all key facilities constituencies should therefore be brought together to form a CHPS committee to support the development and management of the program.

An existing committee may serve the need or a new one may be required. Representation should include: finance, site purchasing, design management, specification development, construction management, maintenance and operation, and environmental health and safety. It may also be appropriate to include representatives from the school board and/or community interested in supporting the program. Potential community representatives include federal and state agencies, designers (architects, engineers, landscape architects), contractors, community based organizations, and local utilities.

Develop CHPS Implementation Plan

Once the manager and CHPS Committee have been determined, the next step is to develop a CHPS implementation plan. The plan should identify a district’s CHPS priorities, goals, and strategy, as well as the number and type of school construction projects that will meet CHPS standards. It should include a milestones-based schedule that coordinates the implementation of CHPS with the District’s design and construction program.

Inventory Existing Building Program

To plan and implement a CHPS program, it is first necessary to inventory the number, status, and timing of school construction projects. Projects may be in planning, pre-design, design, or under construction. CHPS can provide benefits at each of these stages, though the potential for benefits will decrease as the project progresses.

Define Priorities and Goals

The CHPS implementation plan should define the district’s high performance priorities and goals. The CHPS Best Practices Manual recommends a number of priorities. The top three are:

- Daylighting (which has been shown to improve student performance)
- Energy efficiency
- Indoor air quality.

Recommended program goals include:

- Program success (recommendation: institutionalization)
- Ensuring long-term benefits for district, staff, and students
- Operating as an integrated part of the district’s facilities program.
Integrate CHPS into Existing Building Program

As stated above, one key goal of the CHPS program should be to integrate CHPS into the district’s ongoing building program. While a CHPS program may require some unique initiatives, it is best if the program is fully integrated into a district’s efforts to, for example, develop 1) design guidelines and specifications, 2) design, construction, and product procurement contracts, and 3) facility management procedures.

Use Technical Assistance and Available Financial Incentives

There are significant resources available to help school districts implement CHPS programs. The key sources include:

The CHPS Best Practices Manual is available online and contains a wealth of information. The Manual’s six volumes are: Planning (Volume I), Design (Volume II), Criteria (Volume III), Maintenance and Operation (Volume IV), Commissioning (Volume V), and High Performance Relocatable Classrooms (Volume VI). The CHPS Web site has a frequently asked questions page, and CHPS will respond to technical questions about the CHPS credits.

*Savings By Design* is a utility-managed energy efficiency design assistance and incentive program available to almost all California school districts. Only a few districts with local municipal utilities are ineligible. Financial incentives are available for both school districts and design teams, and through the whole building and systems approach. The whole building approach is based on performance (energy consumption) and enables the design team to consider integrated solutions; the systems approach examines individual systems and equipment. Facilitate participation, it is recommended that districts with multiple projects sign a master Letter of Interest. In addition, it is recommended that design teams be required to participate in Savings By Design and to use the whole building approach; that the design team begin work with their local utility’s Savings By Design staff early in the schematic design phase; and that Savings By Design recommendations be incorporated into projects to the extent feasible and approved by the District.

*Bright Schools* is available through the California Energy Commission and offers specific services to help California schools become more energy efficient. It is available for new construction, modernization and existing facilities. Bright Schools will identify cost-effective energy-efficient systems and provide design and implementation assistance—at little or no cost.

*Propositions 47 and 55* offer a fixed amount of energy efficiency financial incentives on a first-come basis.

The Division of the State Architect’s *Matrix of Incentive Programs for Sustainable Design* is a compilation of federal, state, local, and utility financial incentive programs available to high performance schools.

*Grant programs* are added to CHPS homepage of the Web site periodically, as well.
School districts throughout California have experience in implementing CHPS programs. Showcase CHPS schools, located throughout the state, provide excellent examples of projects that maximize high performance concepts. The CHPS Web site is a good source of information on these resources.

NYSERDA’s (New York Energy Research and Development Authority) on-line training program provides high performance schools training.

Outline Training Strategy

Facilities staff (design and construction managers) and design teams (architects, engineers, and landscape architects) should be trained in CHPS and in a district’s specific program objectives. CHPS offers free design trainings throughout California and it is recommended that staff and design teams be required to attend. To ensure that these individuals have a clear understanding of how to achieve a district’s high performance priorities and goals, additional district training may be warranted.

Define Monitoring Strategy

To be successful, a CHPS program should be monitored during both design and construction, and during operations. A district’s CHPS implementation plan should define the monitoring strategy, including responsibilities. Possible monitors include the facilities director, CHPS program manager, or the district’s energy analyst.

During design, it is recommended that design teams be required to submit the CHPS scorecard at each of four key phases: schematic design, design development, construction documents, and post-construction. The scorecards should be reviewed to ensure that the District’s requirements are being fully incorporated into each project.

Construction should be also monitored to ensure that all CHPS-related design elements are properly installed and functioning. Commissioning will assist in this process, especially for mechanical and electrical systems.

During operations, long-term monitoring should be conducted to ensure continued performance, measure impacts, and determine occupant acceptance. The monitoring results should both be included in district CHPS reports (see below) and used to improve the program.

Develop District Maintenance and Operations Plan

Without proper maintenance and operations techniques, the benefits of high performance design can be lost. The CHPS Best Practices Manual Volume IV provides guidance for maintenance and operations staff, teachers, and administrators, including strategies for avoiding the improper use of building systems and poor maintenance practices that can greatly diminish the benefits of a high performance school.

A district should also consider adopting two related CHPS credits: The first credit calls for the creation of a school maintenance plan that includes an inventory of all equipment and their preventative maintenance needs, in addition to full participation in state deferred maintenance programs. The credit provides an additional point for fully funding the maintenance plan.
A second CHPS credit specifies the implementation of the EPA’s “Tools for Schools” program or an equivalent. Tools for Schools provides a roadmap to ensure the maintenance of healthy classrooms, including the use of safe maintenance and custodial supplies by all staff, including teachers, and the protection of ventilation systems.

Establish Reporting Requirements

It is valuable to report the progress of the CHPS initiative on a regular basis to all interested parties, in particular to the board of education. The CHPS implementation plan should define the reporting and public outreach strategy. The goal should be that the district’s community is kept abreast of the program and its progress.

Possible reporting items include:

- Number of CHPS schools.
- CHPS Criteria adopted for district-wide implementation, and their education, health, and economic (life cycle) benefits.
- CHPS Criteria implemented in each project.
- Progress in incorporating CHPS language into design guidelines and specifications, and into design team and contractor requests for proposal and requests for bids.
- Design and construction monitoring, including CHPS Scorecard review.
- Training for project managers, design teams, occupants, and maintenance and operations staff.
- Financial incentives and awards and other public recognition from, for instance, Savings By Design, Propositions 47 and 55, CHPS, California's Coalition for Adequate School Housing (CASH), and California Association of School Business Officials (CASBO).

Select and Implement CHPS Credits

Once a CHPS implementation plan is developed and finalized, a district should focus on selecting and implementing individual CHPS credits into the district’s requirements for all new construction, school additions and modernization projects, and maintenance and operation programs. This effort should be undertaken in an organized fashion based on the implementation plan.

Prepare District CHPS Scorecard to Manage Process

The CHPS Scorecard has been developed to help manage both district CHPS programs and individual CHPS projects.

At a district level:

- The Scorecard is a valuable tool for reviewing, prioritizing, and tracking CHPS credits targeted for program-wide implementation.
The district can record each mandated credit in the “baseline” column of the scorecard and indicate the location of this requirement in the district’s design guidelines and specifications.

The Scorecard is a spreadsheet that will keep a running total of the number of points a district has mandated.

The Scorecard can be used to communicate a district’s CHPS requirements to staff and design teams and be attached to design and construction contracts.

For individual projects:

- The Scorecard provides a mechanism for architects to report the status of CHPS credits for individual projects and provide details of their implementation strategy.
- The Scorecard can provide a minimum level of verification because it requires the signatures of a partner of the project’s architectural firm and the district’s project manager. The completed Scorecard should be submitted to CHPS.

Again, it is recommended that the design team submit the CHPS scorecard four times: schematic design, design development, construction document and post-construction. The scorecards should be reviewed by the program manager to ensure that the District’s requirements are being fully incorporated into each project.

CHPS will fully recognize the project upon completion, but it is never too early to submit the scorecard to CHPS as a school in progress.

**Target Previously Implemented Credits and Other Credits Based on District Priorities**

It is recommended that districts select CHPS credits for implementation on a three-tiered basis:

*Tier #1:* Identify CHPS credits previously implemented. These credits may come from one of three sources: 1) many school districts implement CHPS credits before the adoption of a CHPS resolution, often without knowing of their relevance to CHPS; 2) many projects will receive one or more of the “location” Site credits; and 3) each project receives one point for the adoption of a district high performance schools resolution. The first step, therefore, is to claim those credits already earned for other projects.

*Tier #2:* Identify the “low hanging fruit.” Some credits may be easy to implement with minimal or no cost. Examples are cool roofs and light pollution reduction. Cool roofs will be prescriptively required under the 2005 California Title 24 energy efficiency standards.

*Tier #3:* Identify additional target criteria based on the district’s priorities, as identified in the CHPS implementation plan. As necessary, conduct research on these credits. Base any cost/benefit studies on a life cycle assessment.
Ensure Minimum CHPS Criteria are Met

To meet the CHPS requirements, each project must comply with all nine CHPS prerequisites and achieve a minimum point count of 28. There are a number of strategies for districts implementing district-wide programs. For example, districts can:

- Require design teams to determine how to comply without any input from the district.
- Mandate credits totaling 28 points.
- Mandate credits that total less than 28 points and require that architects implement sufficient additional credits to meet the 28 point minimum.
- Mandate more than 28 points (some showcase schools have exceeded 50 points).
- Mandate credits totaling less than or equal to 28 points and encourage or require design teams to achieve a specified point count above 28.

Assign Responsibility for Each Credit

The responsibility for implementing each prerequisite and targeted credit on a district-wide basis needs to be assigned to a district staff person. Someone needs to be accountable for every prerequisite and every targeted credit.

Incorporate Targeted Credits into District Design Guidelines and Specifications

Based on the CHPS implementation plan prioritization list, incorporate each targeted criteria into the district’s design guidelines and specifications. Model specifications are available for many of the CHPS credits.
MANAGE PROGRAM

Project Delivery

Pre-Design Activities (District)

CHPS is most effective if integrated early in the pre-design phase.

Incorporate CHPS Requirements in Design Team RFP/RFQs and Contracts

To ensure that the needed design expertise is obtained, school districts should incorporate language on their CHPS program into design team Requests for Qualifications (RFQs)/Requests for Proposals (RFPs) and contracts, as follows.

In RFP/RFQs:

- State that all schools must qualify as CHPS schools.
- State that all schools must meet the district’s CHPS requirements.
- Make sustainable building/CHPS experience a selection criterion.
- Require that a LEED<sup>®</sup> Accredited Professional be on each team. These professionals have taken an examination that ensures a minimum level of sustainable building knowledge.
- Include someone with sustainable building and/or high performance school experience on the selection committee.

During Pre-Proposal Conferences:

- Explain the district’s CHPS program and its importance.

In design contracts:

- Incorporate the district’s CHPS requirements. As a district’s CHPS requirements may change over time, one option is to have design team contract require that each school be designed to the CHPS Scorecard attached to the individual contract.

Consider CHPS Credits in Facility Programming

A school district’s adopted CHPS credits should be integrated into its programming for new facilities, school additions, and facilities modernization projects.

Consider CHPS Credits in Site Selection

It is beneficial to consider a district’s adopted CHPS credits in selecting new school sites. Specifically, is the site currently farmland, a wetland, a park or a greenfield (discouraged)? Is a site centrally located and can it provide joint use to the community? Is it close to public transit? Can buildings easily be
oriented east-west (with the long walls facing south and north) to enable sunlight to be easily controlled (Energy Performance and Site credits)?

**Provide Training per District Strategy**

District staff and design teams should receive CHPS training before design begins.

**Design Activities (Design Team/District)**

CHPS must be integrated into a project’s design process, and not viewed as an adjunct. The process should begin with the project kick-off meeting.

**Kick-Off Meeting**

The project kick-off meeting should be used to:

- Ensure that the design team is aware of the district’s CHPS related design guidelines and specifications, including the district’s CHPS Scorecard.
- Communicate CHPS-related goals.
- Target credits for implementation (if different from district-required list). It is recommended that, if appropriate, projects target more than the required minimum points to help ensure that the CHPS threshold is met.
- Assign implementation responsibilities for each targeted credit.
- Establish and enforce CHPS monitoring and reporting responsibilities. The design team should be required to submit the project CHPS Scorecard as follows:
  - Schematic Design: Forecast of anticipated CHPS points.
  - Design Development: Detailed account of CHPS points achieved in the school design.
  - Construction Documents (100%): Finalization of credits incorporated into the design, including brief descriptions of the strategy used to achieve each point and the location of the specific language in the design submittal.
  - Post Construction: Once the building is occupied, this scorecard is a final confirmation of CHPS points achieved with certification by a principal of the design firm and the district project manager.

**Encourage Integrated Design**

Designing a high performance school requires an integrated or “whole building” design process, wherein the design team works closely together. An integrated design process will help ensure that the best project is designed and built at the least cost. An example is energy efficiency: if the walls and roof are designed by the architect to minimize energy consumption, the mechanical engineer should be able to downsize the heating and air conditioning system.
Review District CHPS Scorecard

The entire design team, including district representatives, should thoroughly review the district’s CHPS goals for the project, including the district CHPS Scorecard. Each of the mandated credits should be reviewed, a strategy agreed upon, and the primary responsibility for achieving that credit assigned to a member of the team. It is important to recognize that many credits impact other credits, and that it is therefore important to not address each subject in isolation.

Integrate Commissioning and Savings by Design

If commissioning is an adopted CHPS criterion (see “Commission project” below), the district should appoint someone in-house or hire a third-party commissioning agent at the beginning of a project, and the agent should participate in the design process. Similarly, a representative of Savings By Design should be at the kick-off meeting to explain the program’s benefits and requirements and ensure that the necessary forms are completed.

Provide Training per District Strategy

If district staff and design teams have not yet attended a CHPS design training or a follow up training on the district’s CHPS program, training should be required at the beginning of design.

Schematic Design

The design team should submit the project’s CHPS Scorecard to the district, CHPS program manager and to CHPS (to initiate a record of the project for CHPS database) at the end of schematic design. The program manager should review the scorecard, ensure the project meets district requirements, and discuss any concerns or recommendations with the design team.

Design Development

The design team should next submit the project’s updated CHPS scorecard at the end of design development. The appropriate district personnel should review the scorecard to see if the project meets district requirements, and discuss any concerns or recommendations with the design team.

Construction Documents

The design team should submit the project’s CHPS scorecard a third time at the end of construction documents. The appropriate district personnel should review the scorecard, to assess any necessary design and specification modifications.

Value Engineering

The CHPS design elements need to be reviewed during value engineering, as are all other project elements. It is important, however, that the district’s CHPS credits are maintained and the CHPS goals met. Value engineering, therefore, should only be used to determine the optimal strategies for implementing CHPS credits.
Construction Activities (District/Design Team/Contractor)

CHPS-related design elements must be fully implemented during construction. It is necessarily to proactively ensure that this happens.

Prefer Contractors with Sustainable Building Experience

Under a district’s construction bidding requirements, a preference should be included in bid documents for contractors with sustainable buildings experience. Contractors with the relevant experience may be more able to build a successful high performance school.

Train Contractors

During pre-bid and pre-job conferences, it is important to inform contractors of the priority the district places on implementing CHPS credits, and to ensure that any questions are answered. Substitutions that do not meet specified CHPS requirements are therefore not permitted. Elements that may need to be emphasized at pre-bid and pre-job conferences include commissioning and construction IAQ management.

Commission Project

Commissioning is a rigorous quality assurance program often administered by a knowledgeable third party to ensure that a building performs as expected. CHPS’ energy prerequisite requires both system testing and training. Commissioning should be implemented as early in the design process as possible to optimize the benefits.

Develop Facility Maintenance and Operation Plan

Each facility has unique characteristics. To ensure optimal performance, it is therefore important to develop a maintenance and operation plan for each facility. High performance school systems and strategies must be properly maintained to ensure their full and continuing value.

Post-Construction Activities (District/Design Team/Contractor)

At the end of construction, specific tasks must be undertaken to successfully complete a high performance school.

Commission Project

As indicated above, commissioning will help ensure the optimal performance of high performance schools. During post-construction, the commissioning agent must verify installation, functional performance, staff training and documentation, and produce a commissioning report. To earn the final commissioning point, a system and energy management manual must be developed, and there must be a contract in place for a near-warranty end, or post-occupancy, review.
Train Maintenance and Operations Staff

A high performance school’s maintenance and operations staff must be trained in how to properly maintain a facility. There must be a full and complete hand off of the school to those responsible for keeping it fully functional.

Submit Final Project Scorecard to CHPS

At the end of the project, the school’s final project Scorecard, with the signatures of a principal of the architectural firm and the district project manager, must be submitted to CHPS. This will ensure recognition of the school as meeting CHPS Criteria.

Operation Activities (District)

A high performance school project doesn’t end with the completion of construction; it must continue during operation.

Incorporate into Maintenance and Operations Program

The facility’s maintenance and operation plan must be fully implemented to ensure the full benefit of a facility’s high performance school characteristics, especially with regard to indoor environmental quality and resource efficiency.

Evaluate Program

Monitor Program Effectiveness

It is advantageous to have feedback on the effectiveness of a high performance school program. The effectiveness of the CHPS program can be monitored by tracking the cost and benefits, in particular student performance (test scores); average daily attendance; and energy and water savings.

See Volume IV Facilities Management for additional suggestions.

Interview Program Participants

The district staff, students and parents involved in CHPS will have direct experience as to the program’s successes and failures. Interview the program participants to obtain their opinions.

Monitor School Performance

The performance of CHPS schools can be compared to conventional schools to fully realize the savings and benefits of the CHPS schools.

Conduct Periodic Review

It was recommended above that each school district select specific CHPS credits for district-wide implementation. The list of CHPS credits should be periodically reviewed to identify additional credits that may now warrant implementation.
Incorporate Lessons Learned

A CHPS program can be continuously improved. The lessons learned should be incorporated into all elements of a school district’s CHPS program.
Designing High Performance Schools

Once district-wide policy is set, design teams can start the process of designing individual schools. This section outlines the process. A discussion guide to encourage designers to ask pertinent questions of themselves and the project team is included as Appendix C.

DESIGN WITH THE WHOLE-BUILDING IN MIND

Whole-building design is the consideration and design of all building systems and components. It brings together the various disciplines involved in designing a building and reviews their recommendations as a whole. It recognizes that each discipline's recommendations have an impact on other aspects of the building project. This approach allows for optimization of both building performance and cost. Too often, for example, lighting systems are designed without consideration of daylighting opportunities. The architect, mechanical engineer, electrical engineer, contractors, and other team members each have their scope of work and often pursue it without adequate communication and interaction with other team members, resulting in oversized systems or systems that are optimized for non-typical conditions.

Design With the Whole Building in Mind
• Design with the whole building in mind.
• Set goals early.
• Choose and develop the site wisely.
• Protect indoor air quality.
• Optimize acoustics.
• Incorporate daylighting.
• Install high performance electric lighting and controls.
• Use high performance HVAC strategies.
• Choose materials wisely.
• Conserve water.
• Commission the school.
• Use sustainable construction practices.
• Use high performance relocatable classrooms.
• Train the staff and maintain the building.
Even a small degree of integration provides some benefits. It allows professionals working in various disciplines to take advantage of efficiencies that are not apparent when they are working in isolation. It can also point out areas where trade-offs can be implemented to enhance resource efficiency. Design integration is the best way to avoid redundancy or conflicts with aspects of the building project planned by others.

**SET GOALS EARLY**

For a high performance school, team collaboration and integration of design choices should begin no later than the programming phase. The team may be more broadly defined than in the past, including energy analysts, materials consultants, cost consultants, lighting designers, and commissioning agents. Design activities may include charrettes, modeling, and simulations.

Explicitly outlining the design goals for the school as soon as possible is the most important action that school districts can take to influence the performance of their facility.

For best results, high performance goals should be reflected in all aspects of project documentation. Goals established during programming should be clearly stated in the educational specifications, the RFP to select the design team, in the instruction to bidders, and as part of the project summary.

Districts can use the CHPS Criteria (Volume III) to facilitate and streamline the design process. The criteria explicitly quantify what differentiates a high performance school from standard designs. It is a system of pre-requisites and credits divided into categories including Site, Water, Energy, Materials, Indoor Environmental Quality, and District Resolutions.

Districts can use it to clearly communicate their design goals in three ways:

- Specify that the new school must be a “CHPS School” as defined by the CHPS Criteria. This requires the design team earn 28 out of the 81 possible points.
Choose and Develop the Site Wisely Designing High Performance Schools

- Specify that the facility must be a “CHPS School” and earn specific credits that are important to the district. Because the credits are independent of one another, the district can highlight certain high performance features by specifically highlighting individual credits. For example, if the district wants a “CHPS School” that includes daylit classrooms and low-VOC materials, then those particular credits can be identified and required in the contract documents.

- Specify individual credits that are important to the district, but not require them in the design to be a “CHPS School.” Of course, CHPS recommends that schools meet the requirements of the CHPS Criteria, but if this is not possible, then any incremental high performance features that can be incorporated should be specified.

The typical design process for schools begins with programming and selection of the architectural-engineering team. The sooner high performance goals are considered in the design process, the easier and less costly they are to incorporate. Many of the guidelines presented in this document must be considered early in the design process for them to be successful. The figure below illustrates how quickly the opportunities for high performance diminish as the design process progresses.

**CHOOSE AND DEVELOP THE SITE WISELY**

A district faces many issues during site selection. Cost, student demographics, and environmental concerns all influence when sites are acquired and how the district uses them. The site is a crucial element in determining the overall sustainability of the school design. Sites are sometimes purchased years in advance, and some options are out of the control of the districts and/or designers at the time the school is being built. However, districts that are considering multiple sites can substantially lower the environmental impact of the school by carefully choosing their school site, optimizing building orientation, protecting the ecosystems, and designing to control urban heat islands.

**Set Goals Early**

The design process used to achieve high performance schools is fundamentally different from conventional practice. To be most effective, this process requires a significant commitment on the part of design professionals to:

- Meet environmental performance criteria and optimize design choices through simulations, models or other design tools. Life-cycle cost analysis should be used wherever possible.
- Incorporate interdisciplinary collaboration throughout the design and construction process. Integrate all significant building design decisions and strategies—beginning no later than the programming phase.
- Maintain a view of the building and site as a seamless entity, within the context of its community. Work with the understanding that the building exists within a natural ecosystem even when the setting is urban.
- Commission all building equipment and systems to ensure continued optimum performance.
- Provide clear guidance, documentation, and training for operations and maintenance staff. Document high performance materials in the building so that maintenance and repairs can be made in accordance with the original design intent.
- Encourage sustainable construction operations and building maintenance.

**Additional BPM Resources for Site Selection**

**Volume II, Design**

Site selection and planning impact virtually every buildings system. The Site Planning and General Conditions chapters include the most information.
Effective Site Selection

Protecting student health is the most important issue during site selection. Sites must not contain toxins, pollutants, or safety hazards that will impact student well-being. Of particular concern are:

- Hazardous agents, including industrial, agricultural, and naturally occurring pollutants such as asbestos and heavy metals.
- Nearby facilities that might reasonably be anticipated to emit hazardous air emissions or to handle hazardous or acutely hazardous materials.
- Other objects that are potentially harmful if located near a school, such as hazardous pipelines, high voltage power-line easements, railroad tracks, adverse levels of traffic noise, and airports.

To further protect valuable land and open space, districts should consider:

- Channeling development to sites that are centrally located within the student population. Cars driven by parents, guardians, or the students themselves are the largest resource users and sources of transportation-related pollution. Centrally located sites allow more students to walk or bike to school, while reducing the distance cars must travel.

- Entering joint-use agreements in which parts of the school buildings, parks, or recreation space are shared with local community organizations. Joint use is a growing trend across the country. Schools are being integrated with a variety of organizations, from laundromats and coffee shops, to police stations and park districts. Joint use can have a variety of benefits, including increasing campus security, improving community integration, and reducing site acquisition and construction costs.

- Avoiding development on prime farmland, within flood zones, on habitat for threatened or endangered species, or public parkland. Avoid development on greenfields. Greenfields are defined as those sites that have not been previously developed, or have been restored to agricultural, forestry, or park use. Urban redevelopment reduces environmental impacts by utilizing established infrastructure and preserving the open space of undeveloped lands. Care must be taken to ensure that the sites are safe of hazards prior to use.

- Promoting alternative transportation. Locating the site close to public transportation, creating bike facilities and safe access, and offering bus service all reduce the automobile-related pollution.
Orientation

When site conditions permit, orient buildings so that major windows face either north or south. Position classrooms so that light and air can be introduced from two sides. Solar orientation should guide the placement of building and site features. Reduce the impact of exterior noise sources by locating noise sensitive areas, such as classrooms, away from noise producers, like roadways, train tracks, etc.

Space heating and cooling accounts for nearly 20% of all energy consumption in the U.S. Optimal orientation of the building creates opportunities to use the potential contributions of the sun, topography, and existing vegetation for increased energy efficiency by maximizing heat gain (or minimizing heat loss) in winter and minimizing heat gain in summer. In the case of existing buildings, arrangement of interior spaces, strategic landscaping, and modifications to the building envelope can mitigate unfavorable orientation.

Ecosystem Protection

A high performance school protects the natural ecosystem. As much as possible, the school incorporates products and techniques that do not introduce pollutants or degradation at the project site. Designers should take steps to preserve natural features and restore damaged areas whenever possible.

Stormwater runoff is precipitation that flows over surfaces on the site and enters either the sewage system or receiving waters. Stormwater carries sediment and pollutants from the site into the sewage system and/or local bodies of water. In addition, the cumulative runoff throughout the local area requires significant investments in municipal infrastructure to handle peak runoff loads. Reducing the amount of runoff is the most effective way to minimize its negative impacts. Strategies include:

- Significantly reducing impervious surfaces, maximizing on-site stormwater infiltration, and retaining pervious and vegetated areas.
- Capturing rainwater from impervious areas of the building for groundwater recharge or reuse within the building.

Heat Islands

Heat islands are caused when exterior surfaces absorb the sun’s energy and heat up the air near the ground. On the school site, rising temperatures make the school’s air conditioners work harder, increasing energy costs. In a metropolitan area, heat islands substantially increase the amount of energy spent on air conditioning in the summer and exacerbate urban smog problems.

Providing shade is the best way to reduce the heat island effect. Where possible, shade parking lots and walkways, or replace them with vegetation. Alternatively, use materials with a reflectance of at least 30%. These are typically light-colored materials, although some products are now available that are dark, but reflect enough solar radiation to remain relatively cool in direct sun.
For the school itself, use a “cool roof,” which reflects most of the sun’s energy instead of absorbing it into the interior spaces below. Cool roofs have high reflectivity and are typically light colored, although new products are available in a range of colors. Also, cool roofs must have high emissivity and therefore cannot be bare metal.

**PROTECT INDOOR AIR QUALITY**

The quality of the air inside a school is critical to the health and performance of children, teachers, and staff. A high performance school should provide superior-quality indoor air by: eliminating and controlling the sources of contamination; providing adequate ventilation; commissioning the building; and implementing effective operations and maintenance procedures. For years, news reports, scientific inquiries, and educational efforts have brought attention to the symptoms, causes, and solutions to indoor air quality problems.

According to the EPA, the concentration of pollutants inside a building may be two to five times higher than outside levels. Maintaining a high level of indoor air quality is therefore critical for schools. Failure to do so can negatively impact student and teacher performance; increase the potential for long- and short-term health problems for students and staff; increase absenteeism; accelerate deterioration and reduce efficiency of the school’s physical plant; create negative publicity that could damage a school’s image; and create potential liability problems.

**Health Effects**

Indoor pollutants such as chemical toxins and biological agents can create significant health risks and adverse learning conditions. Pollutants can affect a range of body systems and affect health, learning, productivity and self esteem. Health effects can be both transient (sick building syndrome) and long term (building related illness, multiple chemical sensitivity), and may not affect all of classroom occupants in the same way. Symptoms range from mild discomfort and the perception of bothersome odors to severe illness and permanent injury. Health effects include increased rates of infectious diseases (influenza and the common cold, for example), eye and respiratory irritation, allergies and asthma, chronic sinusitis, headaches, and an array of other diseases. Environmental factors such as light quality, acoustics, and overcrowding may also contribute to or create similar problems. Health problems are typically classified as follows:7

- Sick building syndrome (SBS). SBS describes a collection of symptoms experienced by building occupants that are generally short term and may disappear after the individuals leave the building. The most common symptoms are sore throat, fatigue, lethargy, dizziness, lack of concentration,

respiratory irritation, headaches, eye irritation, sinus congestion, dryness of the skin (face or hands), and other cold-, influenza-, and allergy-type symptoms.

- Building-related illness’ are more serious than SBS conditions and are clinically verifiable diseases that can be attributed to a specific source or pollutant within a building. Examples include cancer and Legionnaires’ disease.

- Multiple chemical sensitivities. More research is needed to fully understand these complex illnesses. The initial symptoms of multiple chemical sensitivities are generally acquired during an identifiable exposure to specific VOCs. While these symptoms may be observed to affect more than one body organ system, they can recur and disappear in response to exposure to the stimuli. Exposure to low levels of chemicals of diverse structural classes can produce symptoms. However, no standard test of the organ system function explaining the symptoms is currently available.

Key to the concern about indoor air quality problems in schools is that children are believed to be much more vulnerable than adults to environmental contaminants and injury. Relative to their size, both their breathing rates and metabolic rates are significantly greater than adults. Children will therefore breathe in and metabolize greater doses of airborne toxins than adults in the same environment. Because children’s bodies are actively growing, they absorb and retain more of these toxins. Their defense mechanisms are less effective at preventing contaminants and infectious organisms from entering their bodies, and their immune systems are less able to respond when agents do enter.

In addition, an increasing number of students and staff are coming into the classroom with already highly sensitized respiratory systems. Across the country, student and staff populations have seen sharp increases in both the prevalence and severity of asthma. Rates in urban areas have been especially high.

Pollutants of concern include mold and microbial growth, airborne chemicals (VOCs, carcinogens, reproductive toxins), inorganic chemicals, and airborne particles including dust and dirt. Exposures to

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common molds and damp environments have been associated with childhood respiratory illnesses,\textsuperscript{10} such as persistent wheezing, shortness of breath, and bronchitis. Molds typically cause health problems when large quantities of air-borne spores are inhaled.

School districts have the power to control their indoor air quality. Because of the diverse range of pollutant sources and the potentially high costs of corrective actions, schools should focus on prevention. Many no-cost and low-cost approaches are available to prevent problems. In general, a high performance school should provide superior quality indoor air by:

- Eliminating and controlling the sources of contamination, including mold
- Providing adequate ventilation
- Commissioning the building
- Implementing effective operations and maintenance procedures.

**Controlling Mold**

Mold is a natural part of the environment, and some mold spores can be found floating around just about everywhere. But, mold will only start to grow indoors when it finds sufficient food and moisture to survive. Because mold decomposes dead organic material, food for mold is present in every building. Cellulose materials, such as wood and the paper backing of gypsum board (drywall), are particularly susceptible to mold growth. Ceiling tiles, insulation, and carpets (adhesive and dirt) can also support mold growth.

However, the real determinant for indoor mold problems is the presence of moisture. There are numerous sources, but among the most common are rain and plumbing leaks, condensation on cold surfaces, and poor control of humidity in the air. Buildings that are free of moisture problems will not have indoor mold problems. Preventing water from entering the building, as well as designing ways for

water to get out of the building, are the most important considerations for reducing indoor mold problems.

The following tips for designers and builders will help prevent moisture infiltrating and/or staying in interior or cavity spaces.

- Use adequate capillary breaks (coarse gravel) and polyethylene vapor diffusion retarders beneath concrete slabs.
- Divert groundwater, rain or irrigation, using overhanging roofs and gutters/downspouts to collect roof rain and divert it from the foundation.
- Incorporate a “drainage plane” to collect water that enters the building assembly and diverts it. Condensate drain should empty 6 ft. plus (spec may be more) from building, not next to it.
- Use proper flashings around any openings in the building envelope, such as windows, and vents.
- Install vapor diffusion and air flow retarders on the interior side of building assemblies in cold climates and on the exterior side of building components in hot, humid climates.
- Ventilate building cavities such as attics, crawlspaces, and walls.
- Specify hard floors near entryways (and walk-off mats).

The EPA’s Tools for Schools has information on mold remediation and prevention at www.epa.gov/iaq/molds/.

In areas where indoor mold growth is become a problem, it is essential that the underlying moisture source (the leak, the drainage problem, or ventilation deficiency) be remedied as part of the clean up. Area containment is also important when removing moldy materials from the school.

**Adequate Ventilation**

Adequate ventilation is the cornerstone of good indoor air quality. Ventilation is critical to removing indoor pollutants from the classroom, and state building codes specify minimum ventilation rates for schools. National standards recommend 20 cubic feet per minute (cfm) per person. In California, the law requires 15 cfm per person, although 20 cfm should be considered. Unfortunately, many schools never meet these guidelines. A 1995 California Energy Commission (CEC) report found that schools
consistently had sub-standard ventilation rates, and one in three classrooms were ventilated at less than half the legal minimums. Other times, sufficient ventilation is entering the room, but it is not distributed effectively to all the occupants. Districts and designers must ensure that the proper amount of air is reaching all of the students in the school. Of particular concern are portable classrooms with loud HVAC systems. Teachers are commonly forced into the unacceptable compromise of turning off noisy air conditioners (and sacrificing ventilation) to communicate with their students.

**Maintenance**

Maintenance practices are crucial to preventing indoor air quality problems.

Mold and microbial growth are the largest potential problems. Any moisture intrusions or spills must be cleaned up thoroughly and immediately to prevent mold from growing. Dead mold spores are often as dangerous as live spores, so prevention is crucial. Once mold is established, it can be very difficult to effectively remediate. All teachers and staff should be trained on how to prevent and identify mold.

HVAC systems must be regularly inspected and maintained to ensure adequate ventilation rates. Filters should be regularly replaced to ensure their effectiveness.

Maintenance practices themselves can introduce and/or remove pollutants. Regular carpet and floor cleanings minimize surface dust. Many cleaning solutions emit VOCs and other chemicals that can remain in the classrooms and cause indoor air quality problems. Districts should consider using interior surfaces that require less frequent or less toxic maintenance practices. Districts should also evaluate their cleaning and landscape management products and consider less toxic alternatives. Herbicides and pesticides are of particular concern. Districts should employ integrated pest management techniques to minimize the use of toxic materials. For more information see the Maintenance and Operations volume of the Best Practices Manual.

**Envelope Design**

By designing the envelope to reduce moisture build-up through condensation, mold growth can be avoided.

**Materials selection**

By requiring architects to specify safe materials and materials that resist growth of molds and mildews, indoor air quality problems may be avoided.

**Commissioning**

By documenting design intent and verifying building systems performance, commissioning is a valuable way to ensure that indoor air quality has been properly addressed.
OPTIMIZE ACOUSTICS

Over the past few decades, a variety of studies have shown that learning is improved in quieter classrooms. These studies have also shown that classroom noise causes a particular learning barrier for children with hearing impairments or learning disabilities, or students who speak English as a second language.

Since as many as 1/3 of students in a typical classroom fall into these categories of extra sensitivity to poor acoustics, meeting the acoustic standard can make a significant difference in learning levels.

Standard S12.60

To address these issues, the American National Standards Institute (ANSI) and the Acoustical Society of America (ASA) developed a 2002 voluntary standard for acoustics—a standard similar to those already in use by the World Health Organization and other countries.

S12.60 is a national standard that details acoustical performance criteria, setting maximum limits for several categories of learning spaces. Some of the criteria outlined in the standards include (for the typical California classroom of 960 ft² with a 10-ft ceiling):

- **Noise Levels**—35 dBA (A-weighted decibels)
- **Reverberation**—0.6 seconds
- **Noise Isolation**—Sound transmission class (STC) 50—60 materials for wall, floor-ceiling, and roof-ceiling assemblies (depending on the kind of space) adjacent to classrooms.

Particularly in schools that are already built and would require retrofits to meet the standard, administrators and designers wonder what will have to be eliminated from the budget to fund acoustic retrofits. Many existing classrooms today reach 50–60 dBA and higher, so costs for retrofit could be

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Designing High Performance Schools
Optimize Acoustics

For new construction, for a classroom built at $190/ft^2, some sources estimate a cost of $5.70/ft^2 increase in costs.

S12.60 was approved in 2002 as a voluntary standard, meaning that it is a national recommendation for classroom design and not required. States, school districts, and other code organizations can adopt the standard to make them mandatory. The standard was submitted to the International Code Council for inclusion in the 2003 International Building Code, though it was rejected because of questions about cost burden to schools and other concerns. In California, no policymaking agency has adopted the standard.

CHPS, in tandem with the recommendations, strongly recommends setting maximum classroom background noise levels at 35 dBA for all classrooms.

Design Principles

The information and tools needed to design classrooms for high acoustical performance are readily available, and can be used to ensure that any newly constructed classroom provides an acoustic environment that positively enhances the learning experience for students and teachers.

Several acoustical issues provide perfect examples to illustrate the design trade-off decisions that sometimes need to be made in high performance schools. For example, increasing the amount of exterior glazing will increase the amount of noise intrusion from outdoor noise sources unless the acoustical performance of the glazing is increased. Standard building construction and glazing cannot easily control exterior noise intrusion from traffic and/or aircraft. Care should be taken to maintain the acoustical integrity of the building shell while providing fresh air. Operable windows are highly recommended for indoor air quality, but typically do not provide a high degree of sound isolation and should be avoided in areas with high exterior noise levels. Similarly, internal glass fiber duct lining is often prohibited to preserve good indoor air quality. However, not allowing glass fiber duct lining to be used significantly increases the complexity of noise control. Districts and designers often need to evaluate these conflicts on an individual level and make choices based on their design priorities and goals.

Quieter HVAC Systems

ANSI/ASA Standard S12.60-2002 sets an aggressive goal for noise levels in classrooms. To meet the standard, school designers will need to look at all sources of noise in a classroom—external sound sources from traffic or flight patterns, noise from adjacent spaces, and sound sources within the room.
Creating an acoustically favorable classroom environment requires a properly defined acoustical goal, accurate sound data, acoustical analysis, detailed specifications, and careful construction.

HVAC equipment is one critical element to consider during this process. Though not the only source of background noise in the classroom, HVAC equipment is often the predominant source. Careful design and location of new HVAC equipment and/or assessment of existing systems is critical, ideally working with an acoustic engineer.

HVAC equipment can be located in the classroom itself, near the classroom, or away from the classroom in a central location. In all cases, selecting components rated by the Air Conditioning and Refrigeration Institute is important as well as carefully designing the rooms and equipment is important.

- In-room HVAC systems can consist of unducted unit ventilators, fan coils, PTACs (packaged terminal air conditioners), and mini-split ductless air conditioning units. Avoiding these systems is the best option, acoustically, since it may not be possible to meet S12.60 with in-room systems.

- Near-room HVAC systems can be an effective S12.60 solution. Near-room systems can include ducted unit ventilators, fan coils, water-source heat pumps, and single-zone rooftop units. Typically, four ceiling diffusers—spaced out evenly—are needed to meet the 35 dBA standard for the average classroom.

- Centrally located HVAC—a large rooftop or airhandler system—usually provides the lowest noise levels.

For retrofits, or if HVAC can’t be located away from the classroom, some things can be done to reduce the noise of HVAC systems in existing in-room systems, including:

- Lowering fan speeds/adding fan modulation and experimenting to see how much noise reduction is gained at lower speeds. Make sure fan motor can handle the speed change.
- Relocating noise sources (compressors) outside of the room (split systems).
- Expanding/softening wall and ceiling assemblies to absorb noise and lower reverberation time.

With central HVAC units, noise can be further controlled using the following techniques:

- Adding internally lined supply and return path ductwork to unit or at least lining the last 7 ft of the duct work to the room—but be sure that the liner material is maintained carefully to avoid indoor air quality degradation.
- Considering the function of rooms near the sound source and use high-STC materials to keep noise out.
- Avoiding the use of large, noisy cubic feet-per-minute VAV (variable air volume) units.
- Considering displacement ventilation.

**INCORPORATE DAYLIGHTING**

Daylighting forms the cornerstone of sustainable, high performance design for schools. Affecting occupants on both conscious and subconscious levels, it provides light to see the environment and to do work, a natural rhythm that determines the cycles of days and seasons, and biological stimulation for hormones that regulate body systems and moods. In addition, it offers opportunities for natural ventilation and tremendous energy savings in electrically lit interiors.

These advantages of daylighting translate to higher performance in schools. Recent research has shown that children achieve significantly higher test scores in classrooms that are daylit than in those that are not, making daylighting one of the best building-related investments for the learning environment.

- Higher performance—Performing visual tasks is a central component of the learning process for both students and teachers. A high performance school should provide a rich visual environment—

**A Closer Look—High Tech High, Los Angeles CA.**

Los Angeles Unified School District completed High Tech High in 2004, as the only school designed specifically to train students for the “high technology careers of tomorrow.” The architects, Berliner and Associates, incorporated many energy efficient daylighting strategies to maximize efficiency and comfort.

The school uses skylights and roof monitors to bring in controlled natural light and reduce reliance on electric lighting systems. The school uses high clerestories to maximize penetration of light deep into building spaces with many common areas having thermal mass flooring to take advantage of this feature. “In addition, the high north orientated side lighting in the commons and the curving configuration of the roof will allow natural light to penetrate the full width of this part of the building and provides shared light to adjacent spaces.”

The school also used high performance window glazing to minimize solar heat gain and solar heat loss in the winter while maintaining excellent levels of daylight.

Source: Berliner and Associates
one that enhances, rather than hinders, learning and teaching—by carefully integrating natural and electric lighting strategies, by balancing the quantity and quality of light in each room, and by controlling or eliminating glare.

- Reduced operating costs—When properly designed, daylighting systems can also substantially reduce operating costs. The first step is decreasing the need for electric lighting, which can account for 35%–50% of a school’s electrical energy consumption. As an added benefit, waste heat from the lighting system is reduced, lowering demands on the school’s cooling equipment. The savings can be as much as 10%–20% of a school’s cooling energy use. And daylight provides these savings during the day when demand for electric power is at its peak and electricity rates are at their highest.

As straightforward as these advantages appear, they do not just happen. The design team must work together using the principles of integrated design to maximize the effectiveness of daylighting systems, and the building occupants need to be educated about how the systems work. Lighting options range from no-cost and low-cost choices to sophisticated state-of-the-art systems. It’s important to communicate daylighting goals clearly with the design team, and find a solution that fits the budget.

**Basic Principles**

The following six principles (discussed further in the Lighting chapter of Volume II) provide fundamental guidance in designing daylit schools:

**Control Direct Sunlight Penetration**

Direct beam sunlight is an extremely strong source of light. It is so bright, and so hot, that it can create great visual and thermal discomfort. Daylight, on the other hand, which comes from the blue sky, from clouds, or from diffused or reflected sunlight, is much gentler and can efficiently provide excellent illumination without the negative impacts of direct sunlight. Good daylighting design typically relies on maximizing the use of gentle, diffuse daylight, and minimizing the penetration of direct beam sunlight. In general, sunlight should only be allowed to enter a space in small quantities, as dappled light, and only in areas where people are not required to do work.

**Provide Gentle, Uniform Illumination**

Daylight is most successful when it provides gentle, even illumination throughout a space. Evenly diffused daylight will provide the most energy savings and the best visual quality. Achieving this balanced diffuse daylight throughout a space is one of the greatest achievements of a good daylight designer.

The arrangement of reflective surfaces that help to distribute the light are just as important as the arrangement of daylight openings for providing gentle, uniform illumination. Whenever possible, place daylight apertures next to a sloped or perpendicular surface so the daylight washes either a ceiling or a
Incorporate Daylighting

wall plane, and is reflected deeper into the space. It is essential to recognize that walls and ceilings are part of the daylighting design. For greatest efficiency and visual comfort, they should be painted white or a very light color that has a high light reflectance value.

Avoid Glare

Excessively high contrast causes glare. Direct glare is the presence of a bright surface (for example, a bright diffusing glazing or direct view of the sun) in the field of view that causes discomfort or loss in visual performance. This can have negative effects on student and staff performance.

Provide Control of Daylight

Daylight is highly variable throughout the day and the year, requiring careful design to provide adequate illumination for the maximum number of hours while contributing the least amount possible to the cooling load. Teachers should have easy access to controls for shades or blinds to adjust light levels as needed throughout the day. These systems should be reliable, easy, and economic to clean and repair. Manually operated controls are slightly less convenient but also less expensive and less likely to need repair.

Integrate with Electric Lighting Design

The daylight and the electric light systems should be designed together so they complement each other to create high quality lighting. This requires an understanding of how both systems deliver light to the space. The electric lighting should be circuited and controlled to coincide with the patterns of daylight in the space, so that the lights can be turned off in areas where daylight is abundant and left on where it is deficient. Controls can either be manual or automatic. Automatic controls use a small photosensor that monitors light levels in the space. Manual controls are substantially less expensive, but need to be convenient and well labeled to ensure their use. Automatic controls guarantee savings, but are more expensive and must have overrides so the teacher can darken the room for audio/visual use.

Plan The Layout of Interior Spaces

Successful daylighting designs must include careful consideration of interior space planning. Since daylighting illuminance can vary considerably within the space, especially with sidelighting, it's important to locate work areas where there is appropriate daylighting. Perhaps more importantly, visual tasks (especially the teaching wall) should be located to reduce the probability of discomfort or disability glare. In general, work areas should be oriented so that daylighting is available from the side or from above. Facing a window may introduce direct glare into the visual field, while facing away from a window may produce shadows or reflected glare.
INSTALL HIGH PERFORMANCE ELECTRIC LIGHTING AND CONTROLS

Electric lighting is one of the major energy uses in schools. Enormous energy savings are possible through the use of efficient equipment, effective controls, and careful design. Using less electric lighting reduces a major source of heat gain, thus saving air-conditioning energy, increasing the potential for natural ventilation, and reducing the space’s radiant temperature (improving thermal comfort). Electric lighting design also strongly affects visual performance and visual comfort, by maintaining adequate, appropriate illumination and by controlling reflectance and glare. Finally, visual, accessible light and power meters can educate students and faculty about how lighting systems and energy controls work.

Lighting in schools should provide a visual environment that enhances the learning process for both students and teachers, which can occur only if people can perform their visual tasks quickly and comfortably.

Horizontal Illumination

Too often, schools are designed with excessively high horizontal light levels. Many published school lighting design parameters remain based on antiquated standards calling for excessively high horizontal illuminance. Too often, this results in poor lighting quality, reduced visual performance, wasted lighting energy, and high energy and maintenance costs.

A Closer Look—Georgina Blach Intermediate School, Los Altos, CA

This project, part modernization and part new construction, resulted in Georgina Blach becoming a CHPS demonstration school—a school building that demonstrates the feasibility of creating a CHPS high performance school and a school that is intended to serve as an example for other districts implementing the CHPS Criteria.

Throughout the project, Los Altos School District maintained a commitment to energy savings and improved comfort for students and teachers. Effective use of daylighting through clerestories and windows augments electric lighting so that, combined, the two light sources provide 40 foot-candles of illumination on all work surfaces. This is an approved change from the District’s former standard of 70 foot-candles solely from electrical lighting. The school also features automatic daylighting controls: dimming ballasts with photocell controls reduce electric light output when adequate daylight is available and lower ongoing electricity costs.

These, and other energy savings methods, have allowed the school to yield electricity savings of 38% beyond the minimum code requirements along with associated cost savings. Furthermore, a commissioning process was completed that will help ensure that these savings will continue into the future. See the appendix to this document for the full case study.

Source: Ken Rackow, Gelfan RNP

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Daylighting Strategies

The location, orientation, and size of the daylighting apertures are of paramount importance, as are the selection of the glazing materials used and how they are shaded from direct sun. When possible, it’s always better to locate daylighting apertures in the ceiling plane (toplighting). With toplighting, glare is easier to control, and daylight distributions are more even. The other basic strategy, sidelighting, allows daylight to enter through windows in vertical walls. However, controlling glare and providing uniform illuminance is more difficult.

To fully daylight most spaces, the guidelines should be combined with each other or repeated as a pattern across the space. For example, Wall Wash Toplighting on an interior wall could be combined with High Clerestory Sidelighting and View Windows on an exterior wall to fully daylight a classroom. Each guideline represents a daylight delivery system with inherent advantages and disadvantages. They are applicable to all climate regions and should be planned in the schematic design phase. It is appropriate for all climate regions, and should be considered during the programmatic, schematic, and design development phases of a school building project.

View Windows. Provide access to exterior views through view windows for all interior spaces where students or staff will be working for extended periods of time. A view window is vertical glazing at eye level, which provides a view to the exterior or interior adjacent spaces. View windows are essential in all school spaces (except spaces requiring visual privacy) to provide relaxing views and information about exterior natural conditions. They are applicable to all climate regions and should be planned in the schematic design phase.

High Sidelighting—Clerestory and High Sidelighting—Clerestory with Light Shelf or Louvers. High sidelighting clerestories are vertical glazing in an exterior wall above eye level (usually above 7 ft), and can be used in all school spaces to provide deep penetration of daylight. A light shelf is a horizontal panel placed below high clerestory glazing (with a view window generally below it) that improves light distribution as daylight reflects off the top surface of the light shelf or louver onto the ceiling. Use light shelves or louvers with high clerestory glazing in perimeter walls to improve daylight distribution, block direct sun penetration, and minimize glare.

Classroom Daylighting—Wall Wash Toplighting. Use wall wash top lighting for interior classroom walls to balance daylight from window walls, brighten interior classrooms, and make them seem more spacious. Wall wash toplighting provides daylight from above through a linear skylight or monitor to wash an interior wall. The glazing is obscured from direct view by the skylight or monitor well. Daylight is diffused with diffusing glazing, baffles or reflections off of matte reflective light well and interior walls.

Central Toplighting. Use central toplighting in single-story or top floor spaces including classrooms, libraries, multipurpose spaces, and administrative offices to provide high levels of even, balanced daylight across the entire room. Central toplighting is accomplished by a central monitor or skylight (or cluster of skylights) that distributes daylight evenly across the room. Daylight is diffused with diffusing glazing or baffles that can be fixed or operable. Daylight levels are highest directly under the aperture and gradually reduce toward the perimeter of the space.

Patterned Toplighting. Use patterned toplighting in interior spaces that need even, low glare illumination across a large area. Patterned toplighting provides daylight through a two-dimensional grid of skylights or rows of linear monitors (sawtooth or square). Spacing of the pattern is largely a function of the ceiling height. It is especially good for gymnasium, library, and multipurpose or cafeteria spaces.
In 1999, the Illuminating Engineering Society of North America (IESNA) revised its recommended lighting design procedure and issued new recommendations for horizontal illuminance. The recommended horizontal illuminance level for most typical classroom and office reading tasks is now 30 footcandles. Some classroom tasks may justify up to 50 footcandles, so choosing between 30 and 50 is an excellent compromise. Better lighting designs don’t stop with horizontal illuminance levels, but also focus on lighting quality issues such as uniformity, vertical illuminance, and glare avoidance.

**Vertical Illumination**

Achieving adequate vertical illumination is one of the more critical design issues in school lighting. With the exception of desktop reading, nearly all school visual tasks are “heads-up” type activities requiring proper vertical illuminance. In addition, much of the perception of what comprises lighting quality is strongly influenced by vertical illumination. For example, proper wall illumination is a critical factor in obtaining lighting uniformity in classrooms. Similarly, in night environments, vertical illumination that promotes facial recognition is important in creating a sense of safety and security. In addition, good vertical illumination is important for promoting the important school activity of social communication.

**Glare Control**

Light sources that are too bright create uncomfortable glare. In extreme cases, direct or reflected glare can also impair visual performance by reducing task visibility. Glare causes eye fatigue by forcing the eye to work much harder. All sources of light, including daylight, must be carefully controlled to avoid causing discomfort or disabling glare. Common glare problems in classrooms include uncomfortable direct glare from overhead sources, reflected glare from computer screens and whiteboards, and direct glare from uncontrolled windows or skylights.

**Lighting Uniformity**

For the most part, illuminate school building spaces as uniformly as possible, avoiding shadows or sharp patterns of light and dark. Large differences between light and dark spaces forces the eye to constantly adapt to differing light levels and contributes to fatigue. The standard lighting fixture historically used in classrooms (recessed or surface-mounted parabolic fixtures) should be avoided in most spaces. By blocking light from reaching the upper portion of the wall and ceiling, they create a shadowy, cave-like environment. Very bright sources should only be used in high spaces like gyms, or in cove lighting and indirect luminaires in ordinary classrooms and other spaces. The best method of maximizing uniformity
is to make a concerted effort to light vertical surfaces and, where possible, the ceiling. Using light-colored, diffuse surface materials also serves to optimize lighting uniformity.

**Lighting Control Flexibility**

Lighting controls should be designed for flexibility to accommodate the varying nature of many school spaces. In addition to saving energy, multiple level switching or separate circuiting of light fixtures enables selection of different light levels to respond to changing requirements or amounts of natural daylight. Control flexibility increases energy efficiency by encouraging only the use of lights that are needed for the activity at hand. Lighting control systems must be easy to understand and operate. Non-intuitive control interfaces are likely to be ignored at best, and disabled in more extreme cases.

Control flexibility is especially important in classrooms, which typically must accommodate lighting levels for a wide variety of conditions and activities. It is especially critical that teachers have the ability to override any automatic dimming and/or occupancy sensor controls, so that they can switch the lights off manually when necessary.

**Daylight Integration**

To achieve its benefits, daylight must be properly controlled. Integrating electric light with daylight is one of the more challenging aspects of school lighting design. At a minimum, luminaires should be circuited to match how daylight enters the space. In other words, luminaires closest to windows or skylights should be circuited separately from other lights in the space. This promotes daylighting’s potential energy savings by allowing some or all of the electric lighting to be turned off during the day. To maximize energy savings, consider the additional flexibility of dimming ballasts with manual or automatic dimmers.

**USE HIGH PERFORMANCE HVAC STRATEGIES**

A school’s HVAC strategy ties together many important characteristics of high performance design, including energy efficiency, thermal and acoustic comfort, and indoor air quality. When designed, installed, and maintained correctly, HVAC systems are rarely noticed and quietly deliver the benefits of clean, comfortable air. However, if problems arise, HVAC systems can quickly become the largest source of service calls and comfort complaints. Choose the HVAC strategy that optimizes performance over the lifetime of the building, is easy to control, and meets the needs (and maintenance skills) of the district.

**Energy Efficiency**

The HVAC system is one of the largest energy consumers in a school. Even modest improvements in system efficiency can represent relatively large savings to a school’s operating budget. With the highly
Use High Performance HVAC Strategies  

**Designing High Performance Schools**

...efficient systems available today—and the sophisticated analysis tools that can be used to select and size them—there is no reason why every school HVAC system cannot be designed to the highest levels of performance.

Always consider the life-cycle costs of operation and maintenance when choosing an HVAC strategy. To ensure peak operating efficiency, the HVAC system in a high performance school should:

- **Use high efficiency equipment.** When possible, model the energy use of the entire facility with energy modeling software. The U.S. Department of Energy's "Energy Conservation Voluntary Performance Standards for New Buildings" and the ENERGY STAR programs are two places to start when looking for high efficiency equipment. Consider recovery systems that pre-heat or pre-cool incoming ventilation air, and "economizer cycles" for small, packaged systems. In hot, dry climates, consider evaporative cooling.

- **Be "right sized" for the estimated demands of the facility.** Select systems that operate well under part-load conditions and consider standard HVAC sizing safety factors as upper limits. Apply any safety factors to a reasonable base condition for the building: not the hottest or coldest day of the year with maximum attendance, and not the most temperate day of the year with the school half full.

- **Include controls that boost system performance.** Provide individual HVAC controls for each classroom. Consider integrated building management systems that control HVAC, lighting, outside air ventilation, water heating, and building security.

The key to optimizing HVAC system performance is an integrated design approach that considers the building as an interactive whole rather than as an assembly of individual systems. For example, the benefits of an energy-efficient building enclosure may be wasted if the HVAC equipment is not sized to take advantage of it. Oversized systems, based on rule-of-thumb sizing calculations, will not only cost more, but will be too large to ever run at peak efficiency and will waste energy every time they turn on. An integrated approach, based on an accurate estimate of the impact of the high efficiency building enclosure, will allow the HVAC system to be sized for optimum performance. The resulting system will cost less to purchase, use less energy, and run more efficiently over time.

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A Closer Look—Inderkum High School, Sacramento, CA.

The Natomas Unified School District completed Inderkum High School with the design assistance of Nacht and Lewis Architects in Fall 2004 which serves 2,000 students and the North Natomas community. One of its key energy saving high performance features included a geo thermal system instead of a conventional HVAC system. Capital Engineering Consultants Inc. were responsible for this state-of-the-art feature incorporating 500 geothermal wells that sit under the campus parking lot and reach up to 275 feet deep.

The system is a "closed loop earth heat exchange" that taps into the stable temperature of the earth at about 55 degrees. It is also more efficient than a conventional water-cooled heat pump, and has improved maintainability due to the elimination of mechanical cooling towers and gas consuming boilers.

Source: Brian Maytum Nacht & Lewis Architects and Capital Engineering Consultants Inc.

Photo: Steve Whittaker, copyright 2004
Thermal Comfort

Thermal comfort is an important variable in student and teacher performance. Hot, stuffy rooms—and cold, drafty ones—reduce attention spans and limit productivity. They also waste energy, adding unnecessary cost to a school’s bottom line. Excessively high humidity levels can also contribute to mold and mildew. Thermal comfort is primarily a function of the temperature and relative humidity in a room, but air speed and the temperature of the surrounding surfaces also affect it. A high performance school should ensure that rooms and HVAC systems are designed to allow temperature and humidity levels to remain within the “comfort zone” at all points in an occupied space. Thermal comfort guidelines are provided in the chapter on HVAC in Volume II of this manual.

Thermal comfort is strongly influenced by how a specific room is designed (for example, the amount of heat its walls and roof gain or lose, the amount of sunlight its windows let in, whether the windows can be opened) and by how effectively the HVAC system can meet the specific needs of that room. Balancing these two factors—room design and HVAC system design—is a back-and-forth process that continues throughout all the stages of developing a new facility. In a high performance school, the process ends with an optimal blend of both components: rooms configured for high student and teacher productivity served by an energy-efficient HVAC system designed, sized, and controlled to maintain thermal comfort under all conditions.

To provide thermally comfortable spaces:

- Design in accordance with American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE) standards. Standard 55-1992 (with 1995 Addenda) defines thermal comfort standards. When a design incorporates natural ventilation (e.g., operable windows to provide direct outdoor air during temperate weather), consider adjusting the requirements of ASHRAE Standard 55-1992 to account for the impact.

- Install controls and monitor system performance. Provide controls in each classroom to give teachers direct control over thermal comfort. Evaluate the potential impact of such controls on the overall efficiency of the HVAC system. Consider temperature and humidity monitoring as part of the building’s overall energy management system to ensure optimal thermal comfort performance.

- Analyze room configurations and HVAC distribution layouts to ensure all parts of a room are receiving adequate ventilation and that heat gains from windows and skylights are properly controlled.

Additional BPM Resources for HVAC Strategies

Volume II, Design

One chapter is dedicated to HVAC systems.

Volume IV, Maintenance and Operations

Volume IV dedicates an entire chapter to maintenance and operations of HVAC systems.
Acoustics

The chosen HVAC strategy cannot compromise acoustic comfort. Carefully design HVAC and air distribution systems to not exceed recommended noise levels.

CHOOSE MATERIALS WISELY

Hidden within all materials are the resources, energy, chemicals, and environmental impacts of their entire lifecycle, from their production and installation until they are ultimately recycled or buried in a landfill. Interior surfaces and furnishings provide an excellent opportunity to highlight the high performance approach. Environmentally preferable choices simultaneously protect the health of students, staff, and the larger natural environment. As defined by the EPA, environmentally preferable refers to “products or services that have a lesser or reduced effect on human health and the environment when compared with competing products or services that serve the same purpose. The product or service comparison may consider raw materials acquisition, production, manufacturing, packaging, distribution, reuse, operation, maintenance, or disposal (EO 13101, Section 201).

In California, the issue of source control to protect indoor air quality in schools has been addressed on a variety of fronts. The California EPA publishes three key lists of known chemicals of concern (including Proposition 65’s list of carcinogenic chemicals). In 2003, the California Integrated Waste Management Board (CIWMB) and the Department of Health Services (DHS) published the Building Material Emissions Study, a research-based study of chemical emissions from numerous building materials with various recycled contents. The study concluded that recycled content products performed about the same as standard products.

In addition, several state agencies, consultants, and CHPS have created a model specification, called Section 01350, to ensure that the building materials specified also protect indoor air quality and the health of building occupants. DHS expanded several sub-sections of the indoor air quality part of Section 01350 through the development of a Standard Practice, which supercedes the previous versions of small-scale environmental chamber testing as outlined in California Specification 01350.

Designers can achieve points within the CHPS Criteria, Low-Emitting Materials credit by specifying products that meet Section 01350 and the DHS Standard Practice.

Section 01350 and the DHS Standard Practice provide an overview of special environmental requirements for a project by providing specification language on environmental and public health considerations in sustainable building projects.
Though not required, Section 01350 and the DHS Standard Practice are provided as guidance by state agencies and consultants. In fact, Section 01350 is one of the most important sections in design specifications for guiding and controlling the environmental impact of a project.

A portion of Section 01350 and the DSH Standard Practice describe health-based indoor air quality testing protocols for building materials. Section 01350 and the Standard Practice are referenced in the CHPS Low-Emitting Materials Credit. Many manufacturers have or are having their products tested by independent laboratories as specified. You can find a list of products that meet the CHPS Low-Emitting Materials Credit on the CHPS Web site. In addition, the Carpet and Rug Institute’s (CRI) Green Label Plus program provides a listing of manufacturers that produce products that meet CRI’s standards for green carpets (www.carpet-rug.com/).

Section 01350 was originally developed in 2001 for the Capitol Area East End Complex project, a 1.5 million ft², five-building state office building complex. Now, school districts are starting to incorporate Section 01350 and the DHS Standard Practice into their designs—starting in 2004, the Los Angeles Unified School District required that all of its schools meet CHPS criteria for low-emitting materials.

In a high performance school, materials are selected based on their material efficiency and effect on indoor environmental quality. These go beyond the traditional issues of performance, price, availability, and aesthetics. All products have environmental impacts and making product choices will require a balance between material efficiency and indoor environmental quality. It is the intent of this manual to guide school districts to make environmentally preferable material choices based on individual and unique circumstances. So, it is important that the district prioritize their design goals to help find the best balance and protect against inevitable product substitutions that occur in the construction phase and can undermine high performance goals.

Many designers in California are already using low-emission materials at little or no increase in cost. Some materials are already tested, so manufacturers can readily provide the results. Schools can also
save money by working with other districts to share test results and use buying power to negotiate better prices.

**High Indoor Environmental Quality**

Since the majority of a school building’s occupants are children or adolescents with still-developing respiratory systems, protecting the school building’s indoor environmental quality is a fundamental goal in the design of a high performance school. Minimizing VOCs and formaldehyde emissions by complying with Section 01350 and the DHS Standard Practice, using less toxic cleaning products, and minimizing mold growth can keep indoor air quality high.

**Additional BPM Resources for Materials**

*Volume II, Design*

Materials are addressed throughout Volume II. Because Volume II is organized by building system, no single chapter completely addresses all the issues; however the Interior Surfaces and Materials chapter has the most information.

*CHPS Web Site*

See [www.chps.net/manual/lem_overvw.htm](http://www.chps.net/manual/lem_overvw.htm) for more information on efficient materials and a table of Section 01350-compliant products/manufacturers.

**Designing with Efficient Materials**

Material-efficient building products are manufactured in ways that conserve resources, are reused or salvaged, contain recycled content, and/or can be recycled or reused at the end of the building’s service life. Addressing these goals provides significant environmental benefit. According to WorldWatch, buildings account for 40% of many processed materials used (such as stone, gravel, and steel) and 25% of virgin wood harvested. These withdrawals can cause landscape destruction, toxic runoff from mines, deforestation, biodiversity losses, air pollution, water pollution, siltation, and other problems.

Designers should look for materials that meet Section 01350 and the DHS Standard Practice requirements and are:

- **Durable.** These types of materials are proven to offer longer service life compared to other options in a given product category.

- **Reducing waste.** Designing with common, modular dimensions and specifying building systems that precisely fit the module promotes materials conservation. Using preconstructed building elements can also reduce waste. Materials should also be marketed in an environmentally responsible manner, such as products available with minimal packaging.

- **Salvaged or reused.** This includes materials that are refurbished and used for a similar purpose, not processed or remanufactured for another use.

- **Sustainably produced,** which means they are extracted, harvested, or manufactured in an environmentally friendly manner. This includes materials that are grown or cultivated, and can be replaced in a relatively short amount of time (rapidly renewable materials). One example is certified wood products, which are produced from trees grown and harvested from Forest Stewardship Council-certified, sustainably managed forests. Forest Stewardship Council is the accrediting agency for organizations such as the Smart Wood program of the Rainforest Alliance and the Forest...
Conservation Program of Scientific Certification Systems, which oversee forestry practices and certify their sustainability.

- Made with recycled content, which includes materials that have been recovered or otherwise diverted from the solid waste stream, after consumer use (post-consumer) or during the manufacturing process (pre-consumer). Always maximize the amount of post-consumer material since this is waste that would have gone into the landfill. High amounts of pre-consumer content may perpetuate inefficient manufacturing processes. The use of recycled content materials helps address problems of solid waste disposal, energy used during manufacture, and the consumption of natural, virgin resources. Related materials are those made with industrial byproducts (fly ash, for example) and include material that is created as a result of an industrial process.

- Recyclable. These materials can be collected, separated, or otherwise recovered from the solid waste stream for reuse, or from the manufacture or assembly of another package or product.

Set a goal to achieve a minimum recycled content rate of 25% (see Volume III for more information).

Many building products that are resource-efficient materials in one or more ways are now available, and many manufacturers are now making products that comply with Section 01350 and the DHS Standard Practice requirements. See www.chps.net/manual/lem_overvw.htm for more information and a table of compliant products/manufacturers).

Examples of material-efficient wood use are engineered lumber and composite wood products, which can be used for casework and trim as well as for framing. Engineered lumber is manufactured by combining wood fibers with plastic resins to produce high quality, structural products. Sheathing products manufactured in this manner, such as oriented strand board (OSB), wafer board, medium density fiberboard, and particleboard, are made primarily of sawmill waste, but are a potential source of formaldehyde. Likewise, finger-jointed lumber made from wood scraps makes use of material that would otherwise be wasted. And composite lumber composed of particleboard with a veneer of hardwood makes efficient use of fine hardwood for uses such as paneling and doors.

Material efficiency does not stop with material selection. Other important concepts include:

- Designing an area within the building dedicated to separating, collecting, storing, and transporting materials for recycling including paper, glass, plastics, and metals.

- Reducing the amount of construction waste going to landfills with a management plan for sorting and recycling construction waste. Consider a goal of recycling or salvaging 75% (by weight) of total construction, demolition, or land clearing waste.

- The design process also offers opportunity to maximize material efficiency through the use of standard dimensions that reduce waste during construction. Toward this end, the use of modular systems, such as carpet tile instead of carpet, greatly minimizes this particular construction waste. Additional building techniques for minimizing waste include reducing unnecessary corners and angles in the structural footprint and using pre-constructed elements such as modular wall panels.
Other Environmental Considerations

Embodied energy is the energy consumed during the entire life cycle of a product, including resource extraction, manufacturing, packaging, transportation, installation, use, maintenance, and when appropriate, even disposal. Products with low embodied energy are environmentally preferable. Recycled content products can typically be produced using less energy. Since transportation is a component of embodied energy, give preference to products that are locally available.

CONSERVE WATER

Fresh water is an increasingly scarce resource in most areas of California. A high performance school should control and reduce water runoff from its site, consume fresh water as efficiently as possible, and recover and reuse gray water to the extent feasible.

Basic efficiency measures can reduce a school’s water use by 30% or more. These reductions help the local and regional environment while decreasing operating expenses. While the cost savings may be modest now, since water is relatively inexpensive in most areas, there is a strong potential that these savings will rise over time, especially in areas where water is scarce.

- Design landscaping to use water efficiently by reducing water use and specifying hardy, native vegetation. Consider using an irrigation system for athletic fields only, not for plantings near buildings or in parking lots. Where irrigation is used, use high efficiency irrigation technology (e.g., drip irrigation in lieu of sprinklers). If local climate allows, use captured rain or recycled site water for irrigation and “design in” cisterns for capturing rainwater.

- Set water use goals for the school. A good starting point is using 20% less than the baseline calculated for the building after meeting the Energy Policy Act of 1992 fixture performance requirements. This can be reached with a combination of water-conserving fixtures and equipment such as low-flow or waterless toilets and urinals, automatic lavatory faucet shut-off controls, low-flow showerheads, and high efficiency dishwashers and laundry appliances.

A Closer Look—Chartwell School, Seaside, CA
Chartwell School overlooking Monterey Bay reflects a commitment to water conservations. Indoors, they installed plumbing fixtures with automatic sensors, and dual-flush or waterless operation. Outdoors, they planted only native landscaping and used recycled water for any needed irrigation through installation of a rainwater collection system.

Additional BPM Resources for Conserving Water
Volume II, Design
Water Issues are discussed in the Site Planning, General Conditions, and Other Systems chapters.

Volume IV, Maintenance and Operations
Volume IV address water conservation in the plumbing and landscaping chapters.
- Use reclaimed water. Reclaimed water is treated, non-potable water that is an excellent resource for irrigation or flushing toilets. Reclaimed water is available in many areas at low and sometimes no cost.

**COMMISSION THE SCHOOL**

High performance schools can only be achieved with some level of commissioning. No matter how carefully a school is designed, if the building materials, equipment, and systems weren’t installed properly or aren’t operating as intended, the health, productivity, and other benefits of high performance design will not be achieved. Commissioning is a pre-requisite in the CHPS program, and additional credit is available for more extensive commissioning.

Studies show that many building systems will not operate as expected unless they are commissioned. One study of 60 newly constructed, nonresidential buildings revealed that more than half had controls problems, 40% had malfunctioning HVAC equipment, and one-third had sensors that did not operate properly. In many of the buildings, equipment called for in the plans and specifications was actually missing. One-fourth of the buildings had energy management control systems (EMCS), with economizers or variable-speed drives that did not run properly.

**What Commissioning Is**

Commissioning is a systematic process of ensuring that all building systems perform interactively according to the contract documents, the design intent, and the district’s operational needs. Commissioning is occasionally confused with testing, adjusting, and balancing. Testing, adjusting, and balancing measures building air and water flows, but commissioning encompasses a much broader scope of work. Building commissioning typically involves four distinct “phases” in which specific tasks are performed by the various team members throughout the process. The four phases are pre-design, design, construction, and warranty.
The commissioning process integrates the traditionally separate functions of equipment startup; control system calibration; testing, adjusting and balancing; equipment documentation; and facility staff training, as well as adds the activities of documented functional testing and verification.

Commissioning can take place for one building system or for the entire facility; however, the more comprehensive the commissioning, the greater the impact on school performance.

Whichever level of commissioning is chosen, a commissioning provider/agent should be engaged during the schematic design phase or earlier.

It is therefore important that commissioning responsibilities—particularly who will bear the cost of correcting conditions that do not meet specifications—are clearly spelled out in the beginning of the design process.

**What the Commissioning Agent Does**

Although commissioning can begin at the construction phase, it is more cost-effective to begin the process at the pre-design phase, when the project team is assembled.

A description of the agent’s responsibilities per phase follows.

**Design**

- Review the design intent.
- Provide commissioning design reviews.
- Prepare commissioning specifications.
- Prepare a commissioning plan.
- Attend design meetings during the design and planning phase to aid in scope development.
- For retrofit/renovation applications, evaluate integrity of existing equipment.

**Construction**

- Review submittals.
- Perform job site observation.

**Most Commonly Commissioned:**

- HVAC plant
- Building automation controls
- Lighting controls.
- Other Systems to Consider:
  - Mechanical plumbing
  - Electrical
  - Backup emergency power
  - Fire alarm
  - Security
  - Irrigation
  - Kitchen equipment and fume hoods
  - Building envelope
  - Refrigeration equipment
  - Energy management
  - Data networks/communications
  - Security
  - Renewable energy
  - Science lab gas delivery.

While not all commissioning agents may be able to personally commission all of these systems, most can subcontract with other industry experts to cover all potential scopes of commissioning.
- Prepare pre-functional checklist.
- Execute functional performance testing.
- Provide deficiency reports for the owner for incorporation into the punch list.
- Review O&M Manuals.
- Ensure that training of maintenance and operations staff happens per specification requirements.

Warranty
- Perform seasonal testing.
- Conduct short-term monitoring and testing on select systems (such as particularly complex systems).
- Perform an end of warranty review of commissioned systems.

Selecting the Commissioning Agent

One of the most important commissioning decisions a district can make is selecting the commissioning provider and determining who will hold the commissioning provider’s contract.

While it is permissible to select a district expert as the commissioning agent, schools will achieve greater benefits by using a third party. Should an internal expert be selected, make sure that the expert has not been directly involved in the design.

Independent Third Party under Contract to the District

Many owners who have commissioned their buildings recommend using an independent third party. An independent commissioning provider can play an objective role and ensure that the district will truly get the building performance expected. For large and/or complex projects, especially in buildings with highly integrated, sophisticated systems, future savings from commissioning outweigh the slightly higher costs with an additional contract. The Building Commissioning Association (www.bexa.org) and the National Environmental Balancing Bureau (www.nebb.org) are good resources for identifying commissioning providers local to your area.

Architect or Design Engineer overseeing the Commissioning Process

If commissioning requirements in the project specifications are rigorous and detailed, districts may consider having the architect manage the contract of a commissioning provider. The designer chosen to
provide commissioning services must not have responsibility for the design of the project. One advantage of using a designer is that he or she is already familiar with the design intent of the project. Districts considering this option should bear in mind that commissioning is not included in a design professional’s basic fees. Districts should require that all findings of the commissioning process be directly reported to both the designer and to the district as they occur, to manage the potential conflict of interest created by having the commissioning services under the designer.

USE SUSTAINABLE CONSTRUCTION PRACTICES

General and trade contractors have a significant role to play in making efficient use of materials, preventing future indoor air quality problems, and protecting the site from degradation.

**Construction and Demolition Waste Management**

Effective job-site waste management will reduce the amount of construction and demolition (C&D) waste generated and divert materials generated through C&D processes from disposal through reuse (salvage) and recycling.

See the General Conditions and Commissioning chapters of Volume III for more information.

Some waste reduction can be designed into the building project, such as standardized dimensioning, the use of modular or panelized building units, reduced corners and angles in the structural footprint, and layout of openings (see the chapter on Building Enclosure in Volume II). Specifying the use of mechanical fasteners (screws, Velcro) rather than chemical adhesives and solvents will allow components to be easily disassembled and reused. Using mechanical fasteners also avoids some of the indoor air quality problems caused by chemical products, which can affect the health and safety of workers and building occupants.

A readily available goal is to recycle, compost, and/or salvage 50%–75% (by weight) of construction, demolition, and land clearing waste including recycling of corrugated cardboard, metals, concrete brick, asphalt, land clearing debris (if applicable), beverage containers, clean dimensional wood, plastic, glass, gypsum board, and carpet. The cost effectiveness of recycling rigid insulation, engineered wood products, and other materials must also be evaluated.

In general, C&D waste reduction should also reduce overall construction costs, especially as this becomes standard operating procedure and the C&D recycling/reuse infrastructure matures. If revenues from waste reduction, reuse/salvage, and recycling are allocated to the contractor, it gives the contractor both the responsibility and the incentive for waste reduction. Most contractors report that having a good waste reduction program in place results in a cleaner, safer site.
Indoor Air Quality During Construction

Require indoor air quality planning and preventive job-site practices.

Site Protection During Construction

An effective job-site protection plan will describe construction practices that eliminate unnecessary site disturbance, minimize impact on the site’s natural (soil and water) functions, and eliminate water pollution and water quality degradation. Primarily it will include protocols for construction equipment operation and parking, topsoil/vegetation protection and reuse, hazardous materials management, and installation and maintenance of erosion control and stormwater management measures.

Contractor’s Commissioning Responsibilities

Contractors can play a key role in effective commissioning by providing timely documentation, understanding the importance of thorough testing and tuning, paying attention to detail when correcting problems, and in general being responsive to the commissioning agent’s recommendations and requests.

USE EFFICIENT RELOCATABLE CLASSROOMS

Relocatable—or portable—classrooms have been a feature of California schools for years. From a district’s perspective, the two advantages of relocatable classrooms are low initial cost and short time between specification and occupancy. They are intended to provide flexibility to school districts, enabling quick response to demographic changes and providing the ability to be moved from one school to another as demographics change. However, in reality, relocatable classrooms are seldom moved and become permanent fixtures of the school.

The effects of poor indoor air quality in relocatable classrooms are no different from those in permanent classrooms. All school buildings use similar construction and furnishing materials, so the types of chemicals present in indoor air are not likely to be different for relocatable versus permanent classrooms. However, pressed-wood products (often with high concentrations of formaldehyde) are used more in the factory-built relocatable units than in buildings constructed on-site. As result, levels of airborne chemicals may be higher in new relocatable classrooms, especially if ventilation is reduced.

Additional BPM Resources for Relocatable Classrooms
Volume VI, Relocatable Classrooms
CHPS Web Site
CHPS has developed a model specification for a relocatable classroom, which can be found at [www.chps.net](http://www.chps.net).
The most common problems with relocatable classrooms include:

- Poorly functioning HVAC systems that provide minimal ventilation of outside air.
- Poor acoustics from loud ventilation systems.
- Chemical off-gassing from pressed wood and other high-emission materials, compounded by quick occupation after construction or installation of carpets.
- Site pollution from nearby parking lots or loading areas.

The solutions to these problems are the same as recommendations for improving indoor air quality in permanent structures.

Relocatables range in quality. Care should be taken to ensure that money and student health are not compromised on low-quality designs.

**TRAIN THE STAFF AND MAINTAIN THE BUILDING**

Effective maintenance and operations procedures are fundamentally important to sustaining the performance of all building systems. Student health and productivity can be affected when building systems fail to operate as designed. Sub-standard maintenance or incorrect operation of building systems usually results from a combination of factors. First, maintenance budgets are often the first to be reduced or eliminated when money becomes tight. Second, designers and contractors typically provide the building staff minimal or no training on how the building systems are supposed to operate or be maintained. Finally, schools eventually may lose institutional knowledge of the building systems because of staff turnover and lack of communication.
Districts should create and execute a maintenance plan that addresses the following items:

- Educate the staff on the value of maintenance, and how a properly functioning facility will help them educate their students.
- Establish a budget for maintenance.
- Hire qualified staff or contractors to perform tasks.
- Develop a preventative maintenance plan, including schedules for maintenance checks.
- Develop a predictive maintenance program to prevent problems from occurring.
- Use a work order system to track work orders, maintenance performed, and costs for each piece of equipment.
- Ensure that the maintenance staff has proper maintenance and operation manuals.
- Ensure availability of recommended spare parts in the warehouse.
- Provide training to the maintenance staff.

High performance schools are maintenance friendly. Building systems are easy to maintain, and reduced operating costs from energy efficient design frees money that could be directed to support maintenance efforts.

Like commissioning, successful maintenance and operation begins in the design phase of a project. Soliciting input from maintenance and operation staff during the early stages of building design can facilitate good maintenance and operation practices. The more convenient it is for staff to perform regular checks and maintenance on building systems, the better building performance needs can be met and costly maintenance can be avoided. In addition, the installing contractor's responsibilities concerning maintenance and operation should be clearly detailed in the project contract specifications during the design stage, so that the contractor can adjust the bid price accordingly. For instance, specifications should explicitly state that contractors will be required to provide comprehensive maintenance and operation manuals for equipment and provide training for staff.

**Training**

Perhaps the most essential component of maintenance and operation is training. Unless building staff is given the skills to perform quality maintenance and operation practices, there is no hope that a building will continue to perform optimally.

As with all training, instruction should be structured to meet the needs of the administration, teachers, and maintenance staff. Additionally, high performance design urges the clear identification of roles, responsibilities, and budget to ensure that important maintenance information is transferred to the building occupants and not lost in the rush to occupy the building after construction is completed. One example would be the creation of a brief classroom operation manual for teachers. This could be
developed by the designers and distributed to the staff to teach them how to work with the building systems to maximize their comfort. Particular issues to be explained would be how to use the lighting system, HVAC controls, and windows; how to avoid glare when using computers; the best methods for controlling temperature; how to prepare the room for A/V presentations; and any other subjects that are important to the teachers and staff.

By videotaping each training session, including the hands-on start up and shutdown procedures for equipment, building operation staff gains a permanent and inexpensive on-site training aid.

**Preventive Maintenance**

Another important maintenance and operation practice is preventive maintenance. Preventive maintenance can save buildings districts time and money by:

- Maintaining facility operation
- Extending equipment life
- Identifying equipment degradation
- Preventing losses of equipment, time, productivity, and resulting revenue.

Performing regular preventive maintenance can result in energy and cost savings. For example, replacing worn fan belts on a regular basis can save 2%–4% of the energy used to run the fans. Cleaning air filters and cooling coils regularly can save 1%–3% of the building’s energy use for cooling. These basic activities cost very little to perform, but can add up to dramatic savings.

The commissioning provider can assist the owner or facility manager in developing a preventive maintenance plan for a building’s HVAC and electrical systems. Most of the information required for developing a preventive maintenance plan is gathered as part of the commissioning process or can be obtained from the operation and maintenance manuals.
Financing High Performance Schools

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 and do not have to cost more to design and build.

Greg Kats in a recent study for the Massachusetts Technology Collaborative\(^\text{12}\) pegged the initial cost premium at 1.5% to 2.5% of construction cost (excluding site acquisition). A 2004 study by Davis Langdon\(^\text{13}\) looked not just at schools but at all green buildings and concluded that the cost premium is insignificant. CHPS estimates that its criteria can be achieved at a cost as low as $1.50/ft\(^2\) (including soft costs). In summary, the costs range from somewhere between zero and 2.5% of the construction cost (excluding site acquisition).

The benefits, on the other hand are staggering. Kats estimates that the present value of the benefits associated with green schools are 10 to 20 times the costs. These benefits include reduced operating...


\(^{13}\) Matthiesson, Lisa Fay and Peter Morris, Costing Green: Comprehensive Cost Database and Budgeting Methodology, Davis Langdon, 2004
costs for energy, water, and maintenance; reduced absenteeism and associated costs for substitute teachers, reduced liability; reduced environmental impact; increased teacher satisfaction and retention, and increased student learning and teacher performance. The last benefit is perhaps the most important and the most valuable for any school district that looks at the costs and benefits of its program over a long time horizon.

dThis section discusses issues related to financing high performance schools, including life-cycle costing, reduced operating expenses, increased funds, financial incentive and technical assistance programs, avoided costs, and reduced litigation risks.

LIFE-CYCLE COSTING

School facilities are investments. State government and local communities spend millions 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 because they cost more initially.

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 up front but may result in energy savings that pay for the extra costs in a few years and then continue to save the school money 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, waste collection, and other ongoing facility operating costs, enabling 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.

CHPS school districts can expect to save 10%–30% on annual utility costs for new schools and 10%–20% for modernizations compared to a school built to meet Title 24 2005 requirements. 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 CEC estimates that the average annual cost of energy, per student, is $126. Expenditures for electricity and natural gas typically run 2.2%–2.7% of the total school’s budget. High performance design solutions could yield savings of up to $50 per student with aggressive designs. Furthermore, these savings continue to reap more savings as long as they are used as designed. In addition, the CEC also recently found that if schools save 25% in energy costs annually, about $1,000 per classroom could be freed up for other needs. Based on these figures, if a campus holds 30 classrooms, the school could save as much as $30,000 annually in operation costs.

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.

One good illustration of integrated design is daylighting. When properly designed, daylighting systems can substantially reduce the need for electric lighting and lower cooling costs. About half of a school utility bill in California pays for lighting. Because of this, lighting systems are often identified for energy-conserving measures and programs. Daylighting saves energy, and therefore money, in two ways. Most obviously, lights that are off are not using energy. But lights that are off are also not generating heat, allowing the air conditioners to be downsized, work less, and save energy. And daylight

"Through the first 3 months we were using about 30% less energy than at our previous middle school, which is 2/3 the size of Alder Creek Middle School."
Source: Rob Koster Tahoe Truckee Unified School District

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These savings are achievable when compared to the stringency of Title 24 2001 standards. The stringency of the California energy standards is regularly increased. These percentages will therefore change.
provides these savings during the day when demand for electric power is at its peak and electricity rates are at their highest.

However, daylighting alone saves no energy unless the electric lighting system is appropriately controlled and the cooling system is properly sized. To be effective, daylighting must be thoughtfully integrated with the other major building systems.

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.
- 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 $4,300–$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/ft² 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 does not begin to take into effect any utility savings from energy efficiency improvements.

Although many 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 may decrease absenteeism.

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15 Assumes 960 square feet per classroom and 20 classrooms in the school.
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 (for example, daylighting systems, proper HVAC sizing, integrating internal loads from other end uses, proper HVAC installation, and building system modeling). More information is available at www.savingsbydesign.com/.

The CEC’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 to 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, and 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, and contractor selection and 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 www.energy.ca.gov/efficiency/brightschools/info.html.

Standard Performance Contracting is a renovation incentive program funded by utility ratepayers and administered by Pacific Gas and Electric Company, San Diego Gas and 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.

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 and 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 Web site at www.energydesignresources.com/.

CIWMB’s Sustainable Building Task Force Web site contains a funding chart entitled, “California Fiscal Resources for Sustainable Building.” Located at www.ciwmb.ca.gov/GreenBuilding/TaskForce/Blueprint/Incentives.xls, this spreadsheet describes more than 150 incentive programs for sustainable design.

The Sacramento Municipal Utility District and other local utilities have specific incentive programs. Schools in their territories should contact them directly for more information.

**AVOIED COSTS AND LITIGATION RISK**

Students, staff, parents and the local community bear the considerable costs of poor school indoor environmental quality. In the school populations, costs include poor health, reduced learning effectiveness, and increased frustration when indoor environmental quality 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 indoor environmental quality can cause both short-term (reversible) and long-term (chronic) effects in students and staff. Overcrowded, 16 poorly ventilated 17 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 substances that can trigger asthma attacks, sensitize allergy-prone individuals, 18 and cause sinus and respiratory infections. Asthma, for

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example, is an environmentally triggered disease\(^{19}\) that usually begins in childhood,\(^{20}\) chronic instances of which can cause permanent changes in lung structure.\(^{21}\) Other irreversible lung and respiratory illnesses 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 paper estimates that 16–37 million cases of the common cold could be avoided each year in the United States by improvements in building design, for an economic benefit of 6–14 billion dollars.\(^{22}\)

One of the ramifications of school building neglect and its consequent adverse effects on indoor environmental quality is the potential for litigation from students, parents, and staff. Crisis-stage indoor environmental quality problems can be extremely costly, may lead to litigation, and can be detrimental to long-term relations among school administrators, staff, parents, students, and public agencies. The fiscal, political, and social costs of addressing a crisis situation are often far 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 indoor environmental quality complaints escalate.

The threat of increasing indoor environmental quality problems, recognition of adverse health effects from indoor air exposures, and the litigious nature of societal interactions warn that poor indoor environmental quality in schools can threaten the financial stability of local school districts. Between 1999 and 2002 alone, 10,000 toxic mold cases were filed in the United States and Canada, with damages reaching into the tens of millions of dollars.\(^{23}\) For example, a mold lawsuit has been filed against Topsail High and South Topsail Elementary schools in North Carolina.\(^{24}\) Several teachers are suing Fort Myers, Florida, for failing to remediate mold issues.\(^{25}\) For each incident that makes the evening news or is adjudicated in court, many less publicized cases are occurring in other districts.

Building a high performance school helps protect districts from indoor environmental quality problems by designing out potential problems, and verifying and documenting the facility's health.

\(^{19}\) Institute of Medicine 2000


\(^{22}\) Fisk 1999

\(^{23}\) Real Estate Weekly “Protecting Against Toxic Mold Lawsuits” Aug. 28, 2002

\(^{24}\) Morning Star “Costly Cleanup” Nov. 27, 2002

\(^{25}\) AP Online “Mold in Schools Draining Funds” Nov. 24, 2002
The CHPS Process in California

Overall project funding for K-12 schools is a combination of state and local money. California voters have been generous in funding school in recent years. In 1998, Proposition 1A reorganized the school design and approval process under a program called the School Facilities Program and appropriated just under $9.2 billion in bonds. In 2002, Proposition 47 added an additional $13.05 billion in general obligation bonds for construction and renovation of K-12 school facilities and higher education facilities. In 2004, Proposition 55 added an additional $12.3 billion in state funding. The funds allocated to California’s K-12 public school system through these bonds are split between new construction, modernization, hardship, and critically overcrowded schools as shown below.
The CHPS Process in California: Primary Players

### PRIMARY PLAYERS

- **School District**: Districts originate construction process, hire architects, and provide local matching funds.
- **CDE**: California Department of Education (CDE) verifies minimum education specifications and coordinates with DTSC on site approval.
- **DSA**: Division of the State Architect (DSA) approves school plans, verifies plans meet all applicable codes. DSA is the building department.
- **OPSC**: The Office of Public School Construction (OPSC) recommends specific funding to SAB.
- **SAB**: The State Allocation Board (SAB) distributes the state matching share of funding.

Source: CHPS, Inc.

Source: Ed Data Web site: [www.ed-data.k12.ca.us](http://www.ed-data.k12.ca.us)
There are five primary players in the California “Kindergarten-University Public Education Facilities Bond Act” process:

- The school districts are solely responsible for the origination and management of the entire construction process. They must secure local funding, manage the designers and contractors, and are responsible for any changes required for approval and release of the funding.

- The State Allocation Board distributes state bond funds for new construction and modernization of K-12 public schools.

- The Office of Public School Construction (OPSC) is staff to the state allocation board, and as such, develops programs and policies that carry out the School Facility Program's mandates. Duties include processing applications and creating agendas for the State Allocation Board. OSPC is a division of the Department of General Services.

- The California Department of Education School Facilities Planning Division (SFPD) determines whether the site and plans are safe for the children and that the facility supports the educational specifications of the district and state. The SFPD must approve the site and plans and maintains the closest relationship with the district during the process. They publish a range of materials to assist districts through the planning and design process, including Guide to School Site development (2000), School Site Selection and Approval Guide (2000), Educational Specifications (1997), and The Form of Reform (1997). The section of Title 5 California Code of Regulations titled “School Facilities Construction” was updated in November 2000. All school construction must comply with the minimum standards and regulations outlined in Title 5 (subjects include: minimum standards, master plan requirements, minimum distances from power lines and airports, hazardous waste requirements, minimum classroom sizes, waste disposal, surface drainage, traffic and pedestrian safety requirements, etc.).

- The Division of the State Architect (DSA) approves the plans based on structural safety, fire safety, and accessibility. The DSA is also charged with checking for compliance with the state energy efficiency requirements. DSA is a division of the Department of General Services. The Construction Inspector of Record IOR is approved for each school project by the DSA.

The School Facility Program overhauled the way public schools are financed and the roles of the government agencies involved. Basically, School Facility Program streamlined funding by giving districts a per pupil grant for new construction and modernization projects. The amount of state funding depends on the number and grade level of the students served by the new facility. The grants are processed by the OPSC, approved by the State Allocation Board, and intended to be the entire contribution of the state. Under the School Facility Program, districts have greater freedom in managing their projects, but they also bear more responsibility. Any cost overruns are the responsibility of the district, and conversely the district can keep any savings produced by cost efficient construction.

School districts may also choose to fund entire school construction using their own local bonding authority and proceed without the required approval of OPSC. SFPD will need to approve the site.
CONSTRUCTION CONTRACT CONSIDERATIONS

The construction contract documents (contract, plans, and specifications) dictate how a project is constructed. It is important that the construction documents be thorough and unambiguous, because ambiguities are interpreted against the party who prepared the documents, usually the district. Courts often rule that districts have waived or diminished their rights against contractors as a result of such ambiguities. Great care should be taken to ensure that the construction documents clearly mandate and specify the high performance requirements and design criteria.

Districts must also be mindful of Public Contract Code requirements that may impact high performance projects, such as the prohibition against sole source specification provisions. With certain high performance building systems, it is sometimes necessary to specify a product or material of particular brand to ensure optimal performance. However, state law prohibits “sole source” specifications and requires that brand-specific contract provisions list at least two brands and provide bidders the express option of proposing substitutions of equal quality.

In practice, a proposed “equal” seldom is. The architect should be contractually required to review and approve substitution requests by comparing the proposed substitute to the specified product based on applicable criteria, including:

- Does the substitute truly meet or exceed the specified product’s performance?
- Does the substitute come with the same, or better, warranty?
- Does the substitute require extra coordination, installation, or additional redesign cost?
- Does the substitute involve ancillary costs, such as higher maintenance, license, or royalty fees?
- Will the substitute adversely impact progress and project scheduling?

An important exception to the sole source and substitution requirements is provided when the district’s governing board, by resolution, includes in the specifications that a particular brand is being designated as a field test or experiment to determine its suitability for future use. This exception may be applicable to many high performance design components. Additionally, these requirements do not apply when the district is matching a specific brand product already installed or in the course of completion.

Districts may avoid sole source and substitution issues through properly drafted performance specifications that require bidding contractors to demonstrate that the building systems and construction materials proposed in their bids actually satisfy the performance specifications.

Architectural Contract Considerations

Responsibility for developing a clear design rests largely with the project architect and design consultants. Certain provisions should be included in the architect’s contract to facilitate satisfactory performance. The contract should specify as a distinct work activity the architect’s responsibility to
coordinate the work of all design consultants, since high performance design requires a collaborative effort by the entire team. Regular meetings among the entire design team should also be required, with minutes prepared by the architect.

Satisfaction of the CHPS Criteria should be mandated through a performance specification in the architect’s contract. The contract should further require the architect to provide the district a report at the conclusion of design development that is approved by the entire design team and which analyzes different alternatives to satisfy the CHPS Criteria. The district may wish to engage an independent consultant to review this report. The district must then make a clear choice among alternatives so the design can proceed to completion under a definitive and agreed upon plan.

Selecting the Contractor

Most school construction contractors have little experience with high performance design features. However, state law limits districts’ discretion in selecting a contractor through competitive bidding requirements, and provides detailed rules regarding bid document preparation, bid review, and contract award. Districts are required to accept the lowest “responsive” bid from a “responsible” contractor. However, districts may eliminate unqualified contractors by pre-qualifying a pool of prospective bidders, or by defining in the bid package the minimum qualifications of a responsible bidder. The bid package should also identify the information required for a bid to be considered responsive.

Bidder Pre-Qualification

Pre-qualification enables districts to specify in detail the criteria for determining whether a contractor is responsible and qualified to perform the project. The district develops a contractor financial statement form and standardized questionnaire requesting detailed descriptions of the bidder’s experience in high performance construction, including the specific components included in the project design. The questionnaire should also request important general information, such as experience in school construction, history of construction claims, timeliness of performance, and claims against the contractor for not following plans and specifications.

These forms must be required of all prospective bidders and must not subjectively act to limit the project to one particular contractor. Districts must adopt an objective, uniform system of rating contractors that establishes minimum qualifications for bidding the project based on information provided in the completed questionnaires and financial statements. Districts must also develop procedures allowing prospective bidders to contest their pre-qualification status.

Bid Responsiveness

A responsive bid is one that conforms to all material terms of the bid package. A detailed bid package with properly drafted performance specifications for high performance components of the design requires bidders to specify how they intend to satisfy the design criteria, while providing districts appropriate discretion to determine responsiveness. The bid package may also require bidders to
demonstrate that systems and construction materials proposed in their bids actually satisfy the design specifications.

**Bidder Responsibility**

If a district does not opt for pre-qualification, then bidder responsibility is determined once bids are submitted. A responsible bidder is one who has demonstrated attributes of trustworthiness, as well as quality, fitness, capacity, and experience to satisfactorily perform the construction contract. The factors determining responsibility are project-specific, but similar to the pre-qualification criteria discussed above. The bid package should define the minimum qualifications necessary and require bidders to provide a detailed statement describing the relevant experience of the company and its anticipated crew for the project. Before rejecting a low bidder as non-responsible, districts must provide the bidder evidence supporting this determination and an opportunity to rebut by demonstrating their qualifications.

**Selecting the Contract Delivery Method**

In the early stages of project planning, the district must choose a construction contract delivery method, which will dictate the roles of the architect, contractors, and consultants. The most common delivery system in public school construction is design-bid-build. This is the “low-bidder” process, where the district hires an architect to prepare the complete design and then awards the project to a general contractor through competitive bidding.

This system provides districts the advantage of having their own design professional who is not affiliated with the contractor and who can monitor construction for compliance with design. Such oversight is helpful for high performance schools, which often include novel components with which contractors may have little experience. Additionally, this system is well understood by contractors and architects. Each knows their respective roles.

Design-bid-build also has its disadvantages. One important factor for high performance schools is that the contractor joins the project team too late to comment on the design, cost, schedule, or phasing prior to bid when their experience would be most useful. Earlier contractor involvement is desirable because contractors are often unfamiliar with high performance design features and their participation in the design can improve their understanding and “buy-in” on the high performance design. As a more general consideration, the clear demarcation of responsibilities between architect and contractor can engender conflict. Each has financial incentive to attribute problems to the other’s area of responsibility by casting issues as design deficiencies or construction deficiencies. Other disadvantages stem from the linear relationship and separation between design and construction, which necessitates a longer project delivery time and can exacerbate schedule problems.

Several other delivery methods common to private construction are being used increasingly on public projects. Districts wishing to consider these alternative delivery methods should consult with legal counsel to structure the system in a manner that complies with competitive bidding and other legal requirements. The more common alternative methods are discussed below. Each offers different
advantages for high performance schools, which should be evaluated on a project-specific basis to determine the most advantageous method.

**Construction Management/General Contractor (CM/GC)**

CM/GC is an option designed to address the primary disadvantages resulting from late contractor involvement in design-bid-build. The district retains, through competitive bidding, a sophisticated general contractor to act as the CM/GC contractor, preferably from a pool of pre-qualified bidders. This contractor should have solid experience in estimating, scheduling, and managing projects. The CM/GC contractor provides construction management services (including input on design) as a member of the project team during the design phase and helps develop a scope of work for each subcontractor necessary for the project.

CM/GC can be advantageous because the CM/GC contractor is involved in the early stages of design and gains a better understanding of the high performance attributes before construction actually begins. This helps the CM/GC contractor better anticipate items with longer lead times, such as certain high performance construction materials that may not be immediately available from local suppliers. Such early involvement can also help reduce conflict by facilitating better cooperation and teambuilding.

One difficulty with CM/GC arises from the legal requirement that contractors list all major subcontractors at the time of the bid. This is problematic because subcontractors are asked to provide a fixed price at a time when the design is incomplete and their scope of work remains somewhat uncertain. The district may face numerous subcontractor substitution requests as subcontractors refuse to perform at their quoted price after they review the completed design. Districts can avoid this problem by competitively bidding each subcontract based on the completed design and assigning each subcontract to the CM/GC contractor. The project is then constructed under the control of a single contractor similar to design-bid-build.

**Construction Management at Risk (CM-at-Risk)**

The CM-at-Risk is a variation of the CM/GC option. With this approach the CM-at-Risk offers advice and consultation during the design process and helps manage construction costs. During construction the CM-at-Risk acts as a general contractor, scheduling and coordinating work of the various subcontractor trades. Additionally, the CM-at-Risk assumes financial responsibility for meeting schedules and budgets. Responsibility for construction is centralized under a single contract. The school facilities department benefits from pre-construction services, including regular meetings with the architect and subcontractors to discuss schedule, budget and design details or issues.

The CM at-risk approach provides an opportunity for fast-tracking of construction work. The CM, having a central role in the schedule, can decide to begin construction on a portion of the work before the design of an unrelated component is complete.
Design-Build and Bridging

Design-build is when a district enters into a contractual relationship with a single entity that assumes the obligation of furnishing the design, supervision, and construction services required to complete the project. The district hires a consulting architect to develop the project conceptual design, from which a detailed scope of work is created. The design-build contractor fulfills this scope of work by completing the design and constructing the project.

The advantages of design-build are derived from centralizing design and construction responsibilities in a single entity. This makes design-build especially useful for projects such as high performance schools, which require close coordination between design and construction phases. It also enables some design and construction activities to proceed simultaneously, thereby shortening project delivery time in comparison to design-bid-build. The district also benefits from having one point of responsibility, which alleviates much of the traditional blame shifting that often occurs between contractors and architects.

One relatively new variation of design-build is bridging. The district hires a criteria architect to establish performance standards and a preliminary design that is more complete than the conceptual design typically prepared in design-build. The design-builder completes the design and constructs the project, but the criteria architect remains on the project to monitor compliance with the design criteria. The result is an unbundling of the preliminary design from the rest of the project. Bridging provides a combination of key high performance advantages offered by design-bid-build and design-build. Design and construction responsibilities are centralized in a single entity, while the district retains a design professional to protect its interests throughout the project.

Use of design-build and bridging on public works has been limited because of concerns over competitive bidding and subcontractor listing requirements, as discussed above. However, in October 2001, Governor Gray Davis signed into law a bill specifically authorizing design-build for school projects larger than $10 million. For smaller projects, districts can address these concerns by competitively bidding the design-build contract and subcontracts in the manner described for the CM/GC process. This increases the district’s administrative burden, but the advantages provided by alternative delivery methods can sometimes justify the added effort.
Appendix A: Case Studies

CASE STUDY 1: ALDER CREEK MIDDLE SCHOOL

Location: Truckee, CA
School District: Tahoe Truckee Unified School District
Architect: Lionakis Beaumont Design Group

Introduction

Alder Creek Middle School, located in rural Truckee, near Lake Tahoe, opened its doors to students in the fall of 2004 as a CHPS demonstration school. The school was designed to serve 1,000 students in the sixth through eighth grade. Grants from the California Energy Commission (CEC), with additional assistance from the California Integrated Waste Management Board (CIWMB) were helpful in implementing many of the high performance features of the school. The school, using the CHPS Criteria, is a showcase of high performance building strategies including natural daylighting, energy efficiency, healthy indoor air quality, proper acoustics, building commissioning, sustainable materials, waste reduction, preventative maintenance, site protection, and water conservation.

Alder Creek Middle School exceeds Title 24 energy requirements by 20%—quite an accomplishment considering Truckee is one of the coldest climates in the nation.

An expected 25% reduction in energy costs alone will yield at least $17,000 in savings annually.
Appendix A: Case Studies Case Study 1: Alder Creek Middle School

High-Performance Features

To achieve optimal high performance goals, the project designers—Lionakis Beaumont Design Group (LBDG)—employed careful planning and attention to details. The following summary lists some of the high performance features that this project showcases.

Energy

Alder Creek Middle School operates at superior energy performance through achieving the following:

- Energy performance of at least 20% beyond Title 24 (2001)
- Building orientation for maximized southern exposure
- Natural daylighting with integrated sunshades
- High-efficiency indirect lighting with daylight sensors
- High ceilings in classrooms for better defused electric lighting and daylighting
- Thermal insulation benefits from berming building into sloped site
- Ground-source heat pump (with ultra high-efficiency pumps) for heating and cooling
- High-efficiency central boiler for domestic water
- ENERGY STAR-compliant, high-reflectance, high-emissivity roof
- Building systems commissioning.

Recycled-Content Materials

The project received two CHPS points for using eight different types of recycled-content materials. The design team followed the prescriptive approach, using recycled content materials to meet the CHPS Criteria.

The table below shows the recycled-content materials used in the construction of the building.

<table>
<thead>
<tr>
<th>Building Material</th>
<th>Minimum Recycled Content</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acoustical ceiling tiles</td>
<td>80% PC recycled content</td>
</tr>
<tr>
<td>Carpet</td>
<td>50%, including 10% PC plastic</td>
</tr>
<tr>
<td>Concrete</td>
<td>20% PI fly ash</td>
</tr>
<tr>
<td>Fiberglass insulation</td>
<td>20% PI glass</td>
</tr>
<tr>
<td>Rigid, poly insulation</td>
<td>9% PI plastic</td>
</tr>
<tr>
<td>Tackable wall panels (Homasote)</td>
<td>100% PC newsprint wrapped in burlap</td>
</tr>
<tr>
<td>Toilet partitions</td>
<td>40% PI recycled content</td>
</tr>
<tr>
<td>Athletic field</td>
<td>100% recycled rubber from tires</td>
</tr>
</tbody>
</table>
Low-Emitting Materials

The project achieved four points for specifying products that meet the CHPS low-emitting materials standards and the rigorous emissions testing standards outlined in the CHPS Material Specifications Section 01350. These standards were used in the specifications for the State of California’s recent Capitol Area East End Complex Block 225 construction project.

Alder Creek Middle School used materials that comply with the Section 01350 emissions testing requirements including paint, insulation, carpet, and acoustic ceiling tiles.

The Alder Creek Middle School design also specified linoleum floors, which are rapidly renewable materials. The architects and school district gained credit for using Section 01350 certification for paint, carpeting, plywood in cabinets, fiberglass insulation, ceiling tile, and linoleum.

To ensure that certain products meet the Section 01350 standards, the team is worked with manufacturers to determine which products had already undergone the emissions testing. For products that had previously passed the testing requirements, the team determined which products would meet the standards for use in this particular school project.

Construction Waste Management

CIWMB staff provided valuable assistance to Alder Creek Middle School team members, particularly in the areas of recycled-content materials and construction waste management, including helping the district find recycling facilities and develop and waste management plan.

The project team decided to aim for a 50% waste diversion goal for one CHPS point—a goal achievable in a rural area with a limited number of recycling facilities. Some recycling facilities accept construction and demolition (C&D) waste materials in Truckee (concrete and asphalt) and nearby Tahoe City (metal and wood).
In addition, CIWMB provided language for a site waste management section for the project specifications. This was adapted from Section 01565 of the Reference Specifications for Energy and Resource Efficiency, which was prepared by Eley Associates (now Architectural Energy Corporation) for the CEC’s Public Interest Energy Research (PIER).

Financing

The additional first costs associated with the green design for CHPS are expected to be fully recovered through the school’s savings in operations and maintenance costs. These savings will accrue because of the energy and water conservation measures, as well as the use of durable, low-maintenance materials. The expected 25% reduction in energy costs alone will yield at least $17,000 in savings annually.

The CEC grant was made possible from the Department of Energy through the National Association of State Energy Officials (NASEO). The grant stipulated that the project would be a CHPS school and exceed Title 24 by at least 20%.

The project also benefited from Proposition 47 energy efficiency funding. The CIWMB provided additional funds to hire a green building consultant, Simon & Associates, who reviewed the project specifications for CHPS-compliant materials and provided materials research assistance.

Lessons Learned

The school district and many members of the design team were new to the CHPS program, but they have gained valuable knowledge that they will be able to apply to future projects. As is typical for demonstration projects, the project team encountered some challenges as well as successes. Lessons learned included the following:

- **Building Material Emissions Testing:** The CHPS Section 01350 emissions testing standards were relatively new and had not yet been used on many projects. Finding manufacturers that were aware of the testing requirements and that had had their products tested was challenging. This project team helped to encourage the use of rigorous emissions testing for building materials by educating themselves and manufacturers about this protocol.

- **Recycled-Content Targets:** The CHPS prescriptive method of the recycled-content credit is based on the recycled-content targets of the EPA Comprehensive Procurement Guidelines. For some materials, these targets are slightly higher than the State of California’s recommended targets.
outlined in the State Agency Buy Recycled Campaign (SABRC). At first, the team found that it was difficult to find three or more products readily available in the marketplace that meet the EPA’s suggested recycled-content percentages. CIWMB’s matrix of products that meet the EPA’s guidelines was helpful in identifying products to include in the project specifications.

- **Familiarity with Alternative Materials:** As is common, the district and architects were hesitant about using products that they had not used in previous projects. For example, the district had maintenance concerns about the removing graffiti from the plastic toilet partitions which had high levels of recycled content, but after reviewing the product information, district staff found that some recycled-content plastic partitions are more resistant to graffiti than standard products.

- **Materials Cost:** Certain green materials, such as Forest Stewardship Council (FSC)-certified sustainably harvested wood doors, could not be specified for the project because of their higher first cost. There was no cost difference to specify the 82% recycled-content, formaldehyde-free ceiling tiles.

- **Energy Modeling:** The team found that the EnergyPro software calculations did not capture all of the project’s innovative energy saving elements. While the software model does show energy savings exceeding Title 24 (2001) by 20%, the team believes that the building, as designed, is even more efficient.

- **Team Communication and Collaboration:** The process of using the CHPS Criteria was made easier because of good communication between district staff and the architects, and also because the contractor was very receptive to and willing to work with the CHPS program. The project used the lease/lease-back method of construction delivery rather than the typical low-bid process. This allowed the district the flexibility to analyze the cost of multiple materials, which otherwise would not have been possible.

- **Project Specifications:** The fact that many green materials requirements were incorporated throughout the project specifications helped ensure that CHPS-compliant materials were actually purchased for the project. Because the project was bid publicly, the specifications had to list three alternate materials (where this was not possible for unique green materials, the specs could state “No known equal”). LBDG has updated its own master specifications to include some of the CHPS-related materials language.
Appendix A: Case Studies Case Study 2: Georgina Blach Intermediate School

CASE STUDY 2: GEORGINA BLACH INTERMEDIATE SCHOOL

Location: Los Altos, CA
School District: Los Altos School District
Architect: Gelfand RNP Architects

Introduction

Students enrolled at the Georgina Blach Intermediate School (Blach School) in Los Altos, California, walked into a newly remodeled, high-performance school facility in the fall of 2002. The remodeled Blach School—a demonstration project sponsored by Pacific Gas & Electric Company (PG&E) —showed how energy- and resource-efficient technologies could be successfully incorporated in a school renovation project. This project is one of the first schools in California to be designed and built to criteria developed by CHPS.

Before PG&E began its involvement in the renovation project, the district had already selected an architectural firm to design the modernization and expansion at the school. The chosen firm was already inclined to use energy efficient design, and the District was willing to consider innovative design ideas. Therefore, PG&E felt the District and its architectural firm would be well suited for the resources available for a CHPS Pilot School. PG&E approached the District with its proposal for offering energy efficient design assistance, the District accepted, and the demonstration project commenced.

The Blach School was one of CHPS’ and PG&E’s first demonstration projects. The objectives of the project included the following:

- Improving the Blach School’s energy efficiency while maintaining or improving the performance of the school
- Demonstrating proven energy efficient technologies
- Demonstrating a design process that integrated energy efficient elements into the design
- Demonstrating a construction and commissioning process that ensured energy efficient design measures were implemented properly

Georgina Blach has achieved an expected energy savings of 38% over Title 24 energy requirements.
Case Study 2: Georgina Blach Intermediate School

Appendix A: Case Studies

- Identifying barriers to high performance design at this school that could be encountered at other facilities
- Developing information to supplement the CHPS Best Practices Manual
- Documenting the technologies and design process used in the project so that the lessons could be transferred to other school districts.

The project’s success was evaluated based on improvements in building energy performance above California Title 24 requirements and improvements in student performance above the levels previously achieved at Blach School.

The District

Founded in 1909, Los Altos School District in northwest Santa Clara County serves elementary school students in grades kindergarten through eighth. Enrollment in the District has grown each year since 1998, with 3,935 students enrolled in the fall 2001-2002 school year, and expected growth to 4,200 students by 2006.

The District is located on the San Francisco Peninsula about 30 miles south of San Francisco and 15 miles north of San Jose. The area has a mild climate, with average temperatures ranging from 39 to 77 degrees Fahrenheit. The summer average high is 77 degrees and the low is 54 degrees. The winter average high is 58 degrees and the low is 39 degrees. Annual precipitation is approximately 16 in. Relative mean humidity is about 68%. Terrain in the area includes rolling hills, valleys, numerous creeks, and densely wooded areas. Elevations above sea level rise from about 200 to approximately 1,300 ft.

The School

This case study documents the high performance design demonstration project at the Georgina Blach Intermediate School (Blach School) in the Los Altos School District (District) in Los Altos, California. This project is a model for how schools can incorporate high performance, energy- and money-saving design features into their construction and renovation projects. Beginning with a commitment from the District and its architect to create a high-efficiency design, and following through with a highly collaborative process between all parties on the project team, the Blach School project was able to achieve an
expected energy savings of 38 percent over the minimum code requirements. At the same time, Blach School now provides a more comfortable and high quality learning environment for students and staff.

The Blach School serves 450 students in seventh and eighth grades. The District initiated a renovation project to expand the original 30,000 ft² facility to 65,000 ft², as well as modernize eight of the existing buildings. Expansion involved new construction of three classroom buildings, a performing arts building, and a gymnasium. The modernization project included the library, multipurpose building, administration building, and four classroom buildings.

High Performance Features

Daylighting

The final design includes dimmable ballasts and photocells in all of the classrooms. Taking these controls into account, the adjusted lighting power density for the new construction areas is 0.8 watts per ft² and 1.0 watts per ft² for the remodeled areas.

Natural Ventilation

The final design includes two 3-ft doors on opposite sides of each classroom, one 6-ft entrance door, and an operable clerestory. Teachers can open the doors and clerestories to provide natural ventilation. The Architect and Commissioning Agent trained the school staff to use the doors and clerestories to make maximum use of natural ventilation. Door contacts were added to shut off the mechanical cooling and heating when the doors are open. Natural ventilation was also used to cool the gymnasium, which did not have air conditioning. The system consisted of a louver intake with passive louvers and an exhaust fan activated by a thermostat.

Commissioning

Overall, the commissioning process for the Blach School was considered a success. Of the 142 issues identified by the Commissioning Agent, 87 percent were successfully resolved. It is possible that without the commissioning process, many of these items would not have been identified until well after equipment warranty periods had expired. The District was so pleased by the results of the commissioning process that they hired the Commissioning Agent to commission two new facilities currently under design.
Success Factors

The project team implemented specific strategies to help ensure success. First of all, the school district and its architect committed to creating a high-efficiency design. Decisions made early in the design process at the Blach School influenced the project’s final energy efficiency and environmental performance. Most significantly, the architect opted for single-story buildings over two-story buildings because single-story buildings are less expensive, meet seismic requirements more easily, and allow more extensive use of daylighting. The design team also took advantage of the sunny, relatively mild climate in the region in combination with advanced building technologies, such as natural ventilation and dimmable lighting controls, to reduce energy use. Establishing a collaborative process among all parties on the project team was also instrumental in the project’s success. An energy consultant and Title 24 consultant brought technical resources to the project team. These experts provided energy efficiency recommendations, justified the higher cost of energy-efficient systems through cost/benefit analyses, conducted a photometric demonstration to illustrate the importance of lighting quality over quantity, and completed thermal comfort studies that led to a reduction in the size of the cooling equipment. Before construction began, representatives of the school district, the architect, and some of the project contractors also participated in a partnering meeting in order to establish an atmosphere of working together towards a common goal.

The project team also completed a commissioning process to ensure that specific building systems performed according to the design intent and the school district’s operational needs. To meet this goal, the project team carefully developed and followed a commissioning plan for the equipment and control systems. A commissioning agent identified a significant number of issues for resolution, many of which would not otherwise have been discovered until well after equipment warranty periods had expired.

CHPS Scorecard

The Blach School received a score of 35 points on the CHPS Scorecard. The minimum number of points required to qualify as a CHPS school is 28 of possible 81 (obtaining all 81 points is not possible). The project achieved a total of 15 points for energy, including: 10 points for superior energy performance, one point for natural ventilation, three points for commissioning, and one point for energy management systems. The project also received a total of 11 points for indoor environmental quality, including: four points for daylighting in classrooms and three points for low-emitting materials.

Utility Savings

A benefit of high performance design is a reduction in utility bills. Though no formal monitoring and verification of energy savings was conducted, a simple analysis of two months of utility data indicated that the energy efficiency measures were functioning as expected.

Student Performance

An expected benefit of high performance design is a rise in student test scores. This was a challenging metric for this particular project, because the Blach School has consistently placed among the top
schools (scoring over 900) in the Academic Performance Index for the last few years. To determine the impact of daylighting, natural ventilation, and energy efficiency on the teaching environment, an evaluation of the teachers’ perceptions might be of value.
CASE STUDY 3: CAHUENGA NEW ELEMENTARY SCHOOL

Location: Los Angeles, CA
School District: Los Angeles Unified School District
Architect: Fields Devereaux Architects & Engineers

Introduction

The Cahuenga New Elementary School #1 will help relieve overcrowding in the district that currently has hundreds of students being bused to schools in other parts of the city. This K-5 school accommodates 804 students on a traditional calendar and 1,125 on a year-round calendar.

In addition to easing school overcrowding, this school is also the first new facility built since LAUSD passed a resolution in 2002 adopting the CHPS Design Guidelines for their schools. CHPS Executive Board Member Randall Higa presented LAUSD with an award honoring their commitment to high performance schools during the groundbreaking ceremony. High performance features at the school include integrated daylight and electric lighting systems in classrooms, recycled content ceiling and wall panels, resulting in a building 30% more efficient than the California Title 24 energy standards.

Sustainable Design Features

Siting

Light pollution is mitigated with exterior light cutoffs, no off-site trespass, and no night sky illumination. To reduce heat island effect, non-pervious surfaces are shaded and high albido surfaces, open grid pavements, and ample landscaping are employed.
Appendix A: Case Studies Case Study 3: Cahuenga New Elementary School

Stormwater Management

To control stormwater, pervious surfaces were used in the play field area, which is turf and has an infiltration capability of its own and in the courtyard area, which has un-grouted interlocking pavers which allow water to infiltrate between the pavers. Both areas feed into the grassy swale which is constructed to temporarily hold and infiltrate stormwater.

Water

Landscape plants were selected to be climate appropriate, and efficient irrigation techniques were used. Efficient plumbing fixtures are used in all indoor applications.

Energy

A high efficiency gas/electric packed rooftop HVAC unit is used on the top two floors. A split unit heat pump is used on the first floor with a condenser on the roof and fan coils at each classroom. Energy efficiency measures employed will help the school to exceed Title 24 Energy Code by 32%.

Lighting and Daylighting

Daylighting is used in combination with light sensors to reduce the electric lighting use in classrooms, and motion sensors are used to reduce the amount of unnecessary lighting. High quality daylighting is accessible in all classrooms through the use of clearstories. Daylight is augmented by electrical lighting in conjunction with lighting sensors to ensure high quality light through out the day.

Acoustics

Designers carefully selected materials, designed a well-sealed envelope, and took various HVAC design measures to improve the acoustic performance of classrooms. They received two points for improved acoustical performance, and achieved a noise level of 35dbA.

Materials

Low emitting materials and recycled content materials were used at the school. Recycled materials included paint, acoustical ceiling tiles, insulation, and fly ash in concrete. Certified wood and other rapidly renewable materials are also specified. A construction waste recycling goal of over 75% was set.
CASE STUDY 4: CESAR CHAVEZ EDUCATION CENTER

Location: Oakland, CA
School District: Oakland Unified School District
Architect: VBN Architects

Introduction

The Cesar Chavez Education Center is the California Energy Commission's first high-performance school demonstration site. The 95,000-ft² facility consists of two state-of-the-art schools that each house 300 students and share common space, such as a preschool, gymnasium and baseball and soccer fields, with the community. The $20 million school, the first Oakland school built from the ground up in more than 30 years, was designed and built using the Collaboration for High Performance School’s (CHPS) Best Practices Manual as the guideline and a $250,000 grant from the California Energy Commission, which will use the site as a learning tool for school officials and designers.

The school was CHPS-certified with a score of 32 points for high-performance design—including 10 for site, 11 for energy and 9 for indoor environmental quality.

Sustainable Design Features

Water

Low-flow fixtures and other water conserving devices are used to reduce water use at the school.

Energy

Design techniques such as the use of cool roofs, thermal insulation, natural ventilation, and daylighting helped the school to exceed Title 24 energy requirements by at least 20%.

Daylighting

Maximum use of daylighting was planned for classrooms and corridors. Classroom daylighting is coordinated with photo-sensors and supplemental electric light to ensure quality lighting levels and low energy use.
The school incorporates angled bay windows and skylights, as well as photo sensor cells and motion sensors to adjust artificial light automatically. The motion sensors also control the mechanical ventilators in the classrooms.

**Indoor Environmental Quality**

Each classroom has a fan coil unit that brings in outside air and exhausts air out.

Natural ventilation is also used to provide clean air to classrooms in addition to a high efficiency heating ventilation system that maximizes the use of free cooling due to the mild Oakland climate.

CHPS’s guidelines also require classrooms to have a minimum occupied noise level and maximum reverberation level, which was a challenge due to the school’s proximity to a busy city highway and Bay Area Rapid Transit (BART) track. While the school was positioned along the north side to minimize the sound from traveling BART trains, the windows facing the tracks were laminated with an acoustical glazing and used a larger air space than is typically used to further contain noise levels.

**Materials**

Recycled content and low VOC materials are incorporated into the school's design.

- Building materials that emit chemicals were avoided. Instead, the team focused on utilizing non-toxic, ecologically friendly materials such as linoleum and natural cork.
- Recycling also played a vital role in constructing the facility. Whenever possible, materials with a high recycled content such as ceramic tiles made with reused glass were used.
- In addition, the facility was built using fly ash concrete and a steel frame, both ecologically friendly.
- An extensive construction debris/recycling program was also implemented to control the amount of excess waste.

**Joint Use**

The school plan includes a joint use gymnasium, multi-purpose room, and community kitchen. In addition, all open space, playgrounds are open to the community, and there is a community kiosk and a parent resource center.

**Grants/Awards**

Cesar Chavez Education Center was the recipient of the 2002 CEC High Performance School Grant, and won the 2002 School Construction News/Design Share Award of Merit.
Appendix B: Implementation Roadmap & Monitoring Plan
CHPS IMPLEMENTATION FLOWCHART

GOAL: Implement CHPS District wide

Monitor program effectiveness

Evaluate Program

Operation activities Vol IV

Post-construction activities

Constitution activities Vol III-IV

Design activities Vol II-III

Pre-design activities Vol I

Project Delivery

Develop CHPS implementation plan Vol I-IV

Select and implement CHPS credits Vol III

Design Program

Establish CHPS program management

Design Program

Develop

Program

Adopt Policy

Build support for CHPS mandate

Adopt Board resolution

Develop

Program

Manage Program

GOAL: Implement CHPS District wide

Evaluate Program

Operation activities Vol IV

Post-construction activities

Constitution activities Vol III-IV

Design activities Vol II-III

Pre-design activities Vol I

Project Delivery

Develop CHPS implementation plan Vol I-IV

Select and implement CHPS credits Vol III

Design Program

Establish CHPS program management

Develop

Program

Adopt Policy

Build support for CHPS mandate

Adopt Board resolution

Manage Program

Symbols: 

1 ✔

2 ✔

Cx

-use District Scorecard

Provide Training

Commission Project
IMPLEMENTATION ROADMAP

Develop Program

Adopt Policy

The recommended first step for school districts seeking to implement a high performance schools program is to make a formal commitment to CHPS. This commitment will be most effective when it is supported by all of the key CHPS constituencies. The first recommended steps of a CHPS program, therefore, are to:

- Build the necessary constituency to support CHPS
- Have the board of education adopt a CHPS resolution. The resolution should require that all new construction, school additions and modernization projects, and maintenance and operation programs, meet CHPS standards.

See the following Web page for additional information: www.chps.net/chps_schools/districts.htm

Build Support for CHPS Mandate

To ensure a successful CHPS program, it is important that all interested constituencies have an opportunity to learn about and support a CHPS initiative. This is best done by identifying and working with the key players inside and outside the district and by clearly articulating to them the rationale for CHPS.

Schedule a CHPS school district seminar that explains the benefits of high performance schools and provides information on incentive programs that are available to your district.

Include Key Internal and External Players

The constituencies that need to support a CHPS program fall into two classifications: school district staff and outside participants. The weight that each of these needs to play in the adoption of a CHPS resolution will vary with the school district. Some school districts, in fact, have adopted resolutions with minimal participation by internal or external players. It is recommended, however, that school districts collaborate with as many parties as are needed in order to ensure the long-term success of the program.

School district staff will be responsible for implementing CHPS. A CHPS program will therefore be most effective if the key internal groups support the CHPS resolution before it is adopted. The key internal group should include:

- Facilities management (design, construction, operations and maintenance)
- Environmental health and safety officials
Appendix B: Implementation Roadmap & Monitoring Plan

Implementation Roadmap

- Bond oversight committee
- Principals and teachers.

*Outside groups* who may be interested include those impacted by a CHPS mandate and those who can support the initiative with technical and/or financial assistance. Key external groups may include:

- Parents
- CHPS representatives
- Local utilities
- Community based organizations (children and env. groups)

*Use Available Rationale*

A school district’s rationale for adopting CHPS is outlined on the CHPS Web site. In addition, CHPS representatives are available to provide a free school district seminar upon request. In this brief presentation, a CHPS representative will provide an overview of the benefits of high performance schools tailored to a district’s needs. The CHPS School Planning Kit is a worthy means of introducing CHPS to district officials.

There are many reasons why school districts should adopt a CHPS mandate. Most importantly, CHPS schools:

- Increase student performance
- Improve student and staff health
- Lower operating costs
- Reduce absenteeism
- Lessen a school’s impact on the environment
- Take greater advantage of incentive programs
- Gain leverage with vendors and suppliers
- Develop and reuse high performance design elements
- Earn up to 10 CHPS District Resolution credits.

By adopting a CHPS resolution, the district school board acknowledges that high performance criteria are a priority for school construction. CHPS provides the vehicle to qualify and quantify the program. The criteria function as a flexible yardstick so that each district can pursue the credits that match its priority.
A CHPS resolution also provides clear direction for the facilities department. If a district is already implementing high performance schools, a resolution formalizes and provides structure for this effort.

See the following Web page on the benefits of District Resolutions: www.chps.net/chps_schools/index.htm.

**Adopt Board Resolution**

A growing number of California school districts have adopted CHPS resolutions. Adopting a CHPS resolution has become the recognized first key step in implementing a CHPS program.

**Use CHPS’ Model Resolution**

CHPS has developed a model resolution that provides the key recommended language. It is available on the CHPS Web site along with resolutions already adopted by California school districts. Key elements include:

- Require that all new construction, school additions and modernization projects, (and perhaps maintenance and operation programs), meet or exceed the CHPS qualifying threshold
- Establish high performance priorities (according to CHPS Criteria)
- Require the development and presentation to the board of a CHPS implementation plan in a specified timeframe
- Establish ongoing reporting requirements; for example, quarterly and/or annual reports that include the list of adopted or targeted CHPS credits (including their cost and benefit), CHPS scorecards for individual projects and the received financial incentives
- Require that all construction projects participate in Savings By Design (if eligible) and other available design assistance and financial incentive programs
- Require facilities staff to coordinate the CHPS program with the appropriate local, regional, state and federal agencies. Examples include water districts, storm water districts and waste management agencies.

See the following Web page for additional information: www.chps.net/chps_schools/districts.htm.

**Incorporate Policy into Future Local Facilities Bonds**

It is important that school construction bonds incorporate CHPS mandates. The process of issuing a bond typically begins with a needs assessment to determine the building program and budget. The needs assessment should include the costs and benefits of CHPS.

**Design Program**

To implement a CHPS program, a series of steps has been identified that will help a school district smoothly move from the status quo to a high performance design, construction and maintenance
program. The goal is to institutionalize CHPS to make CHPS an integrated, ongoing part of a district’s facilities development and maintenance program.

Establish CHPS Program Management

The first step in designing a CHPS program is to establish program management.

Appoint CHPS Program Manager (i.e., facilities executive)

It is important that a high ranking facilities official, such as the director of facilities, be appointed to manage the CHPS program. Facilities management support and direction is imperative for a CHPS program to be successful because implementing CHPS will require changes to standard project design, construction and maintenance practices.

Establish CHPS Committee (or use appropriate existing committee)

A number of facilities-related responsibilities are impacted by a CHPS initiative. Management-level representatives of all key facilities constituencies should therefore be brought together to form a CHPS committee to support the development and management of the program.

An existing committee may serve the need or a new one may be required. Representation should include: finance, site purchasing, design management, specification development, construction management, maintenance and operation, and environmental health and safety. It may also be appropriate to include representatives from the school board and/or community interested in supporting the program. Potential community representatives include federal and state agencies, designers (architects, engineers, landscape architects), contractors, community based organizations, and local utilities.

Develop CHPS Implementation Plan

Once the Manager and CHPS Committee have been determined the next step is to develop a CHPS implementation plan. The plan should identify a district’s CHPS priorities, goals and strategy, as well as the number and type of school construction projects that will meet CHPS standards. It should include a milestones-based schedule that coordinates the implementation of CHPS with the District’s design & construction program.

Inventory Existing Building Program

To plan and implement a CHPS program, it is first necessary to inventory the number, status and timing of school construction projects. Projects may be in planning, pre-design, design or under construction. CHPS can benefit projects at each of these stages though the potential benefits will decrease the further a project is along.

Define Priorities and Goals

The CHPS implementation plan should define the district’s high performance priorities and goals. The CHPS Best Practices Manual recommends a number of priorities. The top three are:
Daylighting (which has been shown to improve student performance)

- Energy efficiency
- Indoor air quality.

Recommended program goals include:

- Program success (recommendation: institutionalization)
- Ensuring long-term benefits for district, staff and students
- Operating as an integrated part of the district’s facilities program.


**Integrate CHPS into Existing Building Program**

As stated above, one key goal of the CHPS program should be to integrate CHPS into the district’s ongoing building program. While a CHPS program may require some unique initiatives, it is best if the program is fully integrated into a district’s efforts to, for example, develop 1) design guidelines and specifications, 2) design, construction and product procurement contracts, and 3) facility management procedures.

**Use Technical Assistance and Available Financial Incentives**

There are significant resources available to help school districts implement CHPS programs. The key sources include:

The *CHPS Best Practices Manual* is available online and contains a wealth of information. The Manual’s four volumes are: Planning (Volume I), Design (V. II), Criteria (V. III) and Maintenance and Operation (V. IV). The CHPS Web site has a frequently asked questions (FAQ) page, and CHPS will respond to technical questions about the CHPS credits.

*Savings By Design* is a utility-managed energy efficiency design assistance and incentive program available to almost all California school districts. Only a few districts with local municipal utilities are ineligible. Financial incentives are available for both school districts and design teams, and through the whole building and systems approach. The whole building approach is based on performance (energy consumption) and enables the design team to consider integrated solutions; the systems approach examines individual systems and equipment. In order to facilitate participation, it is recommended that districts with multiple projects sign a master Letter of Interest. In addition, it is recommended that design teams be required to participate in Savings By Design and to use the whole building approach; that the design team begin work with their local utility’s Savings By Design staff early in the schematic design phase; and that Savings By Design recommendations be incorporated into projects to the extent feasible and approved by the District.
Appendix B: Implementation Roadmap & Monitoring Plan

**Implementation Roadmap**

*Bright Schools* is available through the California Energy Commission and offers specific services to help California schools become more energy efficient. It is available for new construction, modernization and existing facilities. Bright Schools will identify cost-effective energy-efficient systems and provide design and implementation assistance—at little or no cost.

*Propositions 47 and 55* offer a fixed amount of energy efficiency financial incentives on a first-come basis.

The *Division of the State Architect’s Matrix of Incentive Programs for Sustainable Design* is a compilation of federal, state, local and utility financial incentive programs available to high performance schools.

*Grant programs* are added to CHPS homepage of the Web site periodically as well.

*School districts* throughout California have experience in implementing CHPS programs. Showcase *CHPS schools*, located throughout the state, provide excellent examples of projects that maximize high performance concepts. The CHPS Web site is a good source of information on these resources.

*NYSERDA’s (New York Energy Research and Development Authority) on-line training program* provides high performance schools training.

See the following Web sites for additional information:

- [www.chps.net/manual/index.htm](http://www.chps.net/manual/index.htm)
- [www.chps.net/overview/overviewFAQ.htm](http://www.chps.net/overview/overviewFAQ.htm)
- [www.savingsbydesign.com/](http://www.savingsbydesign.com/)
- [www.energy.ca.gov/efficiency/brightschools/](http://www.energy.ca.gov/efficiency/brightschools/)
- [www.dsa.dgs.ca.gov/Sustainability/incentives.htm](http://www.dsa.dgs.ca.gov/Sustainability/incentives.htm)
- [www.chps.net/chps_schools/index.htm](http://www.chps.net/chps_schools/index.htm)
- [www.hpschooldesigntraining.com/nyserda/home.jsp](http://www.hpschooldesigntraining.com/nyserda/home.jsp)

**Outline Training Strategy**

Facilities staff (design and construction managers) and design teams (architects, engineers and landscape architects) should be trained in CHPS and in a district’s specific program objectives. CHPS offers free design trainings throughout California and it is recommended that staff and design teams be required to attend. To ensure that these individuals have a clear understanding of how to achieve a district’s high performance priorities and goals, additional district training may be warranted.

**Define Monitoring Strategy**

To be successful, a CHPS program should be monitored during both design and construction, and during operations. A district’s CHPS implementation plan should define the monitoring strategy,
including responsibilities. Possible monitors include the facilities director, CHPS program manager or the district’s energy analyst.

During design, it is recommended that design teams be required to submit the CHPS scorecard at each of four key phases: schematic design, design development, construction documents and post-construction. The scorecards should be reviewed to ensure that the District’s requirements are being fully incorporated into each project.

Construction should be also monitored to ensure that all CHPS-related design elements are properly installed and functioning. Commissioning will assist in this process, especially for mechanical and electrical systems.

During operations, long term monitoring should be conducted to ensure continued performance, measure impacts and determine occupant acceptance. The monitoring results should both be included in district CHPS reports (see below) and used to improve the program.

To view a sample scorecard: www.chps.net/manual/documents.htm

Develop District Maintenance and Operations Plan

Without proper maintenance and operations techniques, the benefits of high performance design can be lost. The CHPS Best Practices Manual Volume IV provides guidance for maintenance and operations staff, teachers, and administrators, including strategies for avoiding the improper use of building systems and poor maintenance practices that can greatly diminish the benefits of a high performance school.

A district should also consider adopting two related CHPS credits:

The first credit calls for the creation of a school maintenance plan that includes an inventory of all equipment and their preventative maintenance needs, in addition to full participation in state deferred maintenance programs. The credit provides an additional point for fully funding the maintenance plan.

A second CHPS credit specifies the implementation of the EPA’s “Tools for Schools” program or an equivalent. Tools for Schools provides a roadmap to ensure the maintenance of healthy classrooms, including the utilization of safe maintenance and custodial supplies by all staff, including teachers, and the protection of ventilation systems.

Establish Reporting Requirements

It is valuable to report the progress of the CHPS initiative on a regular basis to all interested parties, in particular to the board of education. The CHPS implementation plan should define the reporting and public outreach strategy. The goal should be that the district’s community is kept abreast of the program and its progress.

Possible reporting items include:

- Number of CHPS schools
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- CHPS Criteria adopted for district-wide implementation, and their education, health and economic (life cycle) benefits
- CHPS Criteria implemented in each project.
- Progress in incorporating CHPS language into design guidelines and specifications, and into design team and contractor requests for proposal and requests for bids
- Design & construction monitoring, including CHPS Scorecard review
- Training for project managers, design teams, occupants, and maintenance and operations staff
- Financial incentives and awards and other public recognition from, for instance, Savings By Design, Propositions 47 and 55, CHPS, CASH and CASBO.

See the following Web pages for additional information:

www.cashnet.org/

www.casbo.org/welcome1.htm

Select and Implement CHPS Credits to Require in All Capital Projects (Modernization and New Construction)

Once a CHPS implementation plan is developed and finalized, a district should focus on selecting and implementing individual CHPS credits into the district’s requirements for all new construction, school additions and modernization projects, and maintenance and operation programs. This effort should be undertaken in an organized fashion based on the implementation plan.

Prepare District CHPS Scorecard to Manage Process

The CHPS Scorecard has been developed to help manage both district CHPS programs and individual CHPS projects:

At a district level:

- The Scorecard is a valuable tool for reviewing, prioritizing and tracking of CHPS credits targeted for program-wide implementation
- The district can record each mandated credit in the “baseline” column of the scorecard and indicate the location of this requirement in the district’s design guidelines and specifications.
- The Scorecard is a spreadsheet that will keep a running total of the number of points a district has mandated.
- The Scorecard can be used to communicate a district’s CHPS requirements to staff and design teams and be attached to design and construction contracts.
- For individual projects:
The Scorecard provides a mechanism for architects to report the status of CHPS credits for individual projects and provide details of their implementation strategy.

The Scorecard can provide a minimum level of verification because it requires the signatures of a partner of the project’s architectural firm and the district’s project manager. The completed Scorecard should be submitted to CHPS.

Again, it is recommended that the design team submit the CHPS scorecard four times: schematic design, design development, construction documents and post-construction. The scorecards should be reviewed by the program manager to ensure that the District’s requirements are being fully incorporated into each project.

CHPS will fully recognize the project upon completion, but it is never too early to submit the scorecard to CHPS as a school in progress.


Target Previously Implemented Credits and Other Credits Based on District Priorities

It is recommended that districts select CHPS credits for implementation on a three-tiered basis:

Tier #1: Identify CHPS credits previously implemented. These credits may come from one of three sources: 1) many school districts implement CHPS credits before the adoption of a CHPS resolution, often without knowing of their relevance to CHPS; 2) many projects will receive one or more of the “location” Site credits; and 3) each project receives one point for the adoption of a district high performance schools resolution. The first step, therefore, is to claim those credits already earned for other projects.

Tier #2: Identify the “low hanging fruit.” Some credits may be easy to implement with minimal or no cost. Examples are cool roofs and light pollution reduction. Cool roofs will be a prescriptive requirement under the 2005 California Title 24 energy efficiency standards.

Tier #3: Identify additional target criteria based on the district’s priorities, as identified in the CHPS implementation plan. As necessary, conduct research on these credits. Base any cost/benefit studies on a life cycle assessment.

See the following Web pages for additional information:

Title 24: www.energy.ca.gov/title24/
www.chps.net/overview/overviewCostEffectiveness.htm

Ensure Minimum CHPS Criteria are Met

To meet the CHPS requirements, each project must comply with all CHPS prerequisites and achieve a minimum point count of 28 (including a minimum of two energy points). There are a number of strategies for districts implementing district-wide programs. For example, districts can:
Appendix B: Implementation Roadmap & Monitoring Plan

Implementation Roadmap

- Require design teams to determine how to comply without any input from the district.
- Mandate credits totaling 28 points.
- Mandate credits that total less than 28 points and require that architects implement sufficient additional credits to meet the 28 point minimum.
- Mandate more than 28 points (some showcase schools have exceeded 50 points).
- Mandate credits totaling less than or equal to 28 points and encourage or require design teams to achieve a specified point count above 28.

Assign Responsibility for Each Credit

The responsibility for implementing each prerequisite and targeted credit on a district-wide basis needs to be assigned to a district staff person. Someone needs to be accountable for every prerequisite and every targeted credit.

Incorporate Targeted Credits into District Design Guidelines and Specifications

Based on the CHPS implementation plan prioritization list, incorporate each targeted criteria into the district’s design guidelines and specifications. Model specifications are available for many of the CHPS credits.


Manage Program

Project Delivery

Pre-Design Activities (District)

CHPS is most effective if integrated early in the pre-design phase.

Incorporate CHPS Requirements in Design Team RFP/RFQs and Contracts

To ensure that the needed design expertise is obtained, school districts should incorporate language on their CHPS program into design team Requests for Qualifications/Requests for Proposals and contracts, as follows.

In RFP/RFQs:
- State that all schools must qualify as CHPS schools.
- State that all schools must meet the district’s CHPS requirements.
- Make sustainable building/CHPS experience a selection criterion.
- Require that a LEED™ Accredited Professional be on each team. These professionals have taken an examination that ensures a minimum level of sustainable building knowledge.

- Include someone with sustainable building and/or high performance school experience on the selection committee.

During Pre-Proposal Conferences:

- Explain the district’s CHPS program and its importance.

In design contracts:

- Incorporate the district’s CHPS requirements. As a district’s CHPS requirements may change over time, one option is to have design team contract require that each school be designed to the CHPS Scorecard attached to the individual contract.


*Consider CHPS Credits in Facility Programming*

A school district’s adopted CHPS credits should be integrated into its programming for new facilities, school additions and facilities modernization projects.

*Consider CHPS Credits in Site Selection*

It is beneficial to consider a district’s adopted CHPS credits in selecting new school sites. Specifically, is the site currently farmland, a wetland, a park or a greenfield (discouraged)? Is a site centrally located and can it provide joint use to the community? Is it close to public transit? Can buildings easily be oriented east-west (with the long walls facing south and north) to enable sunlight to be easily controlled (affects daylighting and energy performance credits)?

*Provide training per District strategy*

District staff and design teams should receive CHPS training before design begins.

*Design Activities (Design Team/ District)*

CHPS must be integrated into a project’s design process, and not viewed as an adjunct. The process should begin with the project kick-off meeting.

*Kick-Off Meeting*

The project kick-off meeting should be used to:

- Ensure that the design team is aware of the district’s CHPS related design guidelines & specifications, including the district’s CHPS Scorecard.
- Communicate CHPS-related goals.
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Implementation Roadmap

- Target credits for implementation (if different from district required list). It is recommended that, if appropriate, projects target more than the required minimum points to help ensure that the CHPS threshold is met.

- Assign implementation responsibilities for each targeted credit.

- Establish & enforce CHPS monitoring and reporting responsibilities. The design team should be required to submit the project CHPS Scorecard as follows:
  
  - **Schematic Design**: Forecast of anticipated CHPS points
  - **Design Development**: Detailed account of CHPS points achieved in the school design
  - **Construction Documents (100%)**: Finalization of credits incorporated into the design, including brief descriptions of the strategy used to achieve each point and the location of the specific language in the design submittal.
  - **Post Construction**: Once the building is occupied, this scorecard is a final confirmation of CHPS points achieved with certification by a principal of the design firm and the district project manager.

Encourage Integrated Design

Designing a high performance school requires an integrated or “whole building” design process, wherein the design team works closely together. An integrated design process will help ensure that the best project is designed and built at the least cost. An example is energy efficiency: if the walls and roof are designed by the architect to minimize energy consumption, the mechanical engineer should be able to downsize the heating and air conditioning system.

Review District CHPS Scorecard

The entire design team, including district representatives, should thoroughly review the district’s CHPS goals for the project, including the district CHPS Scorecard. Each of the mandated credits should be reviewed, a strategy agreed upon, and the primary responsibility for achieving that credit assigned to a member of the team. It is important to recognize that many credits impact other credits, and that it is therefore important to not address each subject in isolation.

Integrate Commissioning and Savings by Design

If commissioning is an adopted CHPS criterion (see "Commission project" below), the district should appoint someone in-house or hire a third-party commissioning agent at the beginning of a project, and the agent should participate in the design process. Similarly, a representative of Savings By Design should be at the kick-off meeting to explain the program’s benefits and requirements, and ensure that the necessary forms are completed.

See the following Web pages for additional information:
Provide Training per District Strategy

If district staff and design teams have not yet attended a CHPS design training or a follow up training on the district’s CHPS program, training should be required at the beginning of design.

Schematic Design

Submit/review project scorecard with anticipated CHPS credits. The design team should submit the project’s CHPS Scorecard to the district.

CHPS Program Manager and to CHPS (to initiate a record of the project for CHPS database) at the end of schematic design. The Program Manager should review the scorecard, ensure the project meets district requirements, and discuss any concerns or recommendations with the design team.

Email: info@chps.net (include “scorecard” in the subject line)
Fax: 415-957-1381
Mail to:
CHPS, Inc.
142 Minna Street, 2nd Floor
San Francisco, CA 94105

Design Development

Submit/review project scorecard with detailed account of achieved CHPS credits.

The design team should next submit the project’s updated CHPS scorecard at the end of design development. The appropriate district personnel should review the scorecard to see if the project meets district requirements, and discuss any concerns or recommendations with the design team.

Construction Documents

Submit/review final project scorecard

The design team should submit the project’s CHPS scorecard a third time at the end of construction documents. The appropriate district personnel should review the scorecard, to assess any necessary design and specification modifications.

Value Engineering

Ensure CHPS credits are maintained.
The CHPS design elements need to be reviewed during value engineering, as are all other project elements. It is important, however, that the district’s CHPS credits are maintained and the CHPS goals met. Value engineering, therefore should only be used to determine the optimal strategies for implementing CHPS credits.

**Construction Activities (District/ Design Team/ Contractor)**

CHPS-related design elements must be fully implemented during construction. It is necessarily to proactively ensure that this happens.

*In Bid Documents, Prefer Contractors with Sustainable Building Experience*

Under a district’s construction bidding requirements, a preference should be included in bid documents for contractors with sustainable buildings experience. Contractors with the relevant experience may be more able to build a successful high performance school.

*Train Contractors*

During pre-bid and pre-job conferences, it is important to inform contractors of the priority the district places on implementing CHPS credits, and to ensure that any questions are answered. Substitutions that do not meet specified CHPS requirements are therefore not permitted. Elements that may need to be emphasized at pre-bid and pre-job conferences include commissioning and construction IAQ management.

*Commission Project*

Commissioning is a rigorous quality assurance program often administered by a knowledgeable third party to ensure that a building performs as expected. CHPS Energy Prerequisite 2: Fundamental Building Systems Testing and Training requires both system testing and training. Energy Credit 4: Commissioning specifies the implementation of a series of fundamental best practice commissioning procedures for 2 points, and an additional series of commissioning tasks for 1 additional point. Commissioning should be implemented as early in the design process as possible to optimize the benefits.

For additional information see the following Web pages:

www.chps.net/links/pdfs/CommissioningProcessGuide.pdf

www.cacx.org/

*Develop Facility Maintenance and Operation Plan*

Each facility has unique characteristics. To ensure optimal performance, it is therefore important to develop a maintenance and operation plan for each facility. High performance school systems and strategies must be properly maintained to ensure their full and continuing value.
Post-Construction Activities (District/ Design Team/ Contractor)

At the end of construction, specific tasks must be undertaken to successfully complete a high performance school.

Commission Project

As indicated above, commissioning will help ensure the optimal performance of high performance schools. During post-construction, the commissioning agent must verify installation, functional performance, staff training and documentation, and produce a commissioning report. To earn the final commissioning point, a system and energy management manual must be developed, and there must be a contract in place for a near-warranty end, or post-occupancy, review.

Train Maintenance and Operation Staff

A high performance school’s maintenance and operation staff must be trained in how to properly maintain a facility. There must be a full and complete hand off of the school to those responsible for keeping it fully functional.

Submit Final Project Scorecard to CHPS

At the end of the project, the school’s final project Scorecard, with the signatures of a principal of the architectural firm and the district project manager, must be submitted to CHPS. This will ensure recognition of the school as meeting CHPS Criteria.

Email: info@chps.net
Fax: 415-957-1381
Mail to:
CHPS, Inc.
142 Minna Street, 2nd Floor
San Francisco, CA 94105

Operation Activities (District)

A high performance school project doesn’t end with the completion of construction; it must continue during operation.

Incorporate into Maintenance and Operations Program

The facility’s maintenance and operation plan must be fully implemented in order to ensure the full benefit of a facility’s high performance school characteristics, especially with regard to indoor environmental quality and resource efficiency.
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Implementation Roadmap

Evaluate Program

Monitor Program Effectiveness

It is advantageous to have feedback on the effectiveness of a high performance school program. The effectiveness of the CHPS program can be monitored by tracking the cost and benefits, in particular student performance (test scores); average daily attendance; and energy and water savings.


Interview Program Participants

The district staff, students and parents involved in CHPS will have direct experience as to the program’s successes and failures. Interview the program participants to obtain their opinions.

Monitor Both CHPS and Conventional School Performance (Air Quality, Energy Use, etc.)

The performance of CHPS schools can be compared to conventional schools in order to fully realize the savings and benefits of the CHPS schools.

Conduct Periodic Review to Identify Additional Credits that Warrant District-Wide Implementation

It was recommended above that each school district select specific CHPS credits for district-wide implementation. The list of CHPS credits should be periodically reviewed to identify additional credits that may now warrant implementation.

Return to “Design Program” (Above) and Incorporate Lessons Learned

A CHPS program can be continuously improved. The lessons learned should be incorporated into all elements of a school district’s CHPS program.
CHPS MONITORING PLAN

Now that your district has succeeded in passing a CHPS resolution and creating an implementation program, it is necessary to monitor the program’s effectiveness. This will allow your district to determine if its high performance goals are being met.

It is incumbent upon each school district to ensure that its CHPS program is being fully implemented at both the district level and in individual projects during design, construction and operation. Monitoring and evaluation should measure the program’s successes and failures, and identify opportunities for improvement.

The CHPS Roadmap Discussion Guide recommends that a district’s CHPS Implementation Plan define the monitoring strategy, including responsibilities. The monitoring strategy should include the following steps.

Designate Monitor

A CHPS program monitor should be designated with the responsibility for coordinating the collection of all information and reporting the findings. Possible candidates include the facilities director, CHPS Program Manager and the district’s energy analyst.

The monitor should be fully knowledgeable of all aspects of the district’s CHPS Implementation Plan, in particular the program’s priorities and goals; how the CHPS guidelines are incorporated into the district’s building program; the incentive programs the district is committed to utilizing; the CHPS training process for both district staff and design teams; the district’s maintenance & operations plan; and finally the CHPS reporting requirements.

Standardize Process

The monitoring strategy should define a standardized process for the collection and reporting of information, including appropriate forms. At a minimum, the strategy should follow the steps recommended in the Discussion Guide:

- During design, require design teams to submit a completed CHPS scorecard during schematic design, design development, and upon completing the construction documents. The district should institute a systematic project review process to ensure that the district’s CHPS requirements are being fully incorporated into each project. Utilize the CHPS scorecard as the key document. The construction document review should include a post value engineering check to ensure that the CHPS-related elements remain in the design.
- Construction should be monitored to ensure that all CHPS-related design elements are properly installed and functioning. If adopted, commissioning will assist in this process, especially for
mechanical and electrical systems. In addition, change orders need to be monitored to ensure that they do not result in the loss of any high performance measures.

- During operation, conduct long-term monitoring to ensure continued performance, measure impacts and determine occupant acceptance. Monitoring should include both the collection of statistical information and interviews with program participants including district staff, students and parents. Once a project is complete and has been commissioned (if commissioning is part of the project), the final scorecard with an accurate rating of the project, should be submitted to CHPS for recognition as a CHPS school.

**Standardize Reporting**

There are many possible issues that can and should be examined through the monitoring strategy. The monitoring results should both be reported to the school board and used to improve the program. The key questions that should be answered include:

**At the District Level**

- Is the CHPS program fully meeting the intent of the Board resolution and the district’s priorities and goals?
- Are all of the program’s elements performing as intended?
- What are the program’s costs and benefits?
- How many construction projects qualified as CHPS schools? How many did not?
- What CHPS credits are being implemented district wide?
- How does the performance of CHPS schools compare with conventional schools for student performance, average daily attendance, energy and water consumption, and other key indicators?
- Are CHPS credits fully integrated into the district’s design guidelines and specifications, and into design team and contractor requests for proposal and requests for bids?
- What financial incentives were received?
- Are there additional CHPS credits that should be adopted for all projects?
- How can the program be improved?

**For Individual Projects**

- Were all of the project’s high performance goals and CHPS credits achieved? If not, which goals were not met, and why?
- Was the project’s CHPS status systematically reviewed during all phases?
Was a final scorecard with both the Program Manager and Architect of Record’s signature submitted to CHPS? Has CHPS recognized the project as meeting the minimum criteria?

If the project was commissioned was it to the district’s advantage? How could the process be improved? Was it applied early enough in the project to have a significant impact?

Were the district-designated incentive program(s) fully utilized?
Appendix C: Discussion Guide

This Discussion Guide presents a step-by-step design process in order to ensure that a high performance school building is achieved.

The guide contains a series of questions, organized by design phase, that the "owners" of a new school (the superintendents, business officials, board members, and others who are guiding the facility development process) can use to make sure their design team actively considers all the key components of a high performance school during every phase of the development process.
USING THE DISCUSSION GUIDE

Over the course of designing and building a new facility, school representatives will meet regularly with their design team to discuss progress. Use the Process Guide to help guide discussion during these meetings.

The Discussion Guide is divided into eight sections corresponding to key phases in the design/development process:

- Programming and goal setting.
- Selecting the A/E team.
- Site analysis.
- Schematic design.
- Design development.
- Construction documents.
- Bidding.
- Construction administration.

At the start of each phase, consult the appropriate section of the Discussion Guide. Throughout this phase of the process, use the list of questions to help frame discussions with the design team. The questions in each section address the key "building blocks" of any high performance school:

- Acoustic comfort.
- Commissioning.
- Daylighting.
- Energy analysis tools.
- Environmentally preferable materials and products.
- Environmentally responsive site planning.
- High performance heating, ventilating, air conditioning systems.
- High performance electric lighting.
- Life-cycle cost analysis.
- Renewable energy.
- Safety and security.
- Superior indoor air quality.
- Thermal comfort.
- Visual comfort.
- Water efficiency.
Programming and Goal Setting

Superior Indoor Air Quality
✓ Has superior indoor air quality been established as a design goal for the school?

Acoustic Comfort
✓ Has good classroom acoustics been established as a design goal for the school?

Thermal Comfort
✓ Has thermal comfort been established as a design goal, especially for the classrooms?

Visual Comfort
✓ Has visual comfort been established as a design goal, especially for the classrooms?

Daylighting
✓ Has providing optimum amounts of daylight been specifically established as a design goal for the school and, in particular, for the classrooms?

Safety and Security
✓ Has security been established as a design goal for the school?
✓ As part of programming, are basic room placements and adjacencies being considered in terms of their effects on safety and security (for example, is the main entrance visible from the administrative offices, etc.)?

Life-Cycle Cost Analysis
✓ Has using some form of life-cycle cost analysis methodology been established as a requirement for the design team?

What methodology will be used?
✓ What basic assumptions (for example, projected life of the facility, projected energy costs, rate of inflation, etc.) have been built into the methodology? Are they agreed to by all parties?

Commissioning
✓ Has commissioning been committed to, and budgeted for, as a basic component of the project?
✓ Has a commissioning agent been engaged?

Energy Analysis Tools
✓ Is the design team required to use an energy analysis tool to help maximize the energy effectiveness of the building?
✓ What tool has been selected?
✓ At what stages in the design process will the tool be used and what types of analyses will be developed?
✓ Has an energy use goal (that is, a maximum amount of nonrenewable energy the school should consume in a year) been established? What is it?

Energy-Efficient Building Shell
✓ Has providing an energy-efficient building shell been established as a goal for the project?
✓ Does the basic programming allow windows on the east and west to be smaller (to reduce unwanted heat gain) and those on the north and south to be larger (to enhance daylighting opportunities)?

Environmentally Preferable Materials and Products
✓ Has using environmentally preferable materials and products been established as a design goal?
✓ Has a goal been set to achieve a minimum 25% recycled content rate?
✓ Is there agreement between the owner and design team as to the types of environmentally preferable materials and products that should be considered for the project? Are these prioritized?

Waste Reduction
✓ Has material efficiency been established as a design goal?
✓ Has construction waste management been established as a goal? Have specific goals for waste reduction been set?

Environmentally Responsive Site Planning
✓ Is preserving natural areas on the site established as a design goal?
✓ Is minimizing stormwater runoff a design goal for the site?
✓ Have goals for alternative transporation been established?
✓ Does the community support the environmental and visual impacts of the school on the site and surrounding area? Have minimizing these impacts been established as a design goal?

High Performance HVAC
✓ Is using high efficiency heating, ventilating, and air conditioning equipment a design goal for the project?
✓ Is “right sizing” this equipment (by accurately predicting demand and sizing the equipment to meet it) a design goal?
✓ Are low noise levels produced by mechanical equipment a design goal for the project?

High Performance Electric Lighting
✓ Is a high performance electric lighting system — especially in the classrooms — a design goal?
✓ Is optimizing the interaction between the electric lighting system and any daylighting strategies a design goal?

Water Efficiency
✓ Has water efficiency been established as a design goal for the project?
✓ Have water use goals for the school been established?

Renewable Energy
✓ Is maximizing the cost effective use of renewable energy a design goal for the project?
✓ What percentage of the projected annual energy use of the facility should be provided by renewable energy systems? Is this percentage agreed to by all parties?
✓ Will the district need to hire a qualified technician to maintain the renewable energy sources? What school district budgets and trade union issues will need to be addressed?
Selecting the A/E Team

Superior Indoor Air Quality

- What is the team’s approach to delivering superior indoor air quality?
- In previous projects how has the team addressed: controlling sources of contaminants in a building, providing adequate ventilation, and avoiding moisture accumulation?
- Have any of their buildings experienced indoor air quality problems that required remedial action?

Acoustic Comfort

- Is there an acoustical consultant on the team?
- How has the team addressed acoustic performance in previous projects?
- What specific strategies has the team used to ensure acoustic quality?
- How has the team applied these strategies in classrooms, multi-purpose rooms, stages, performance/music spaces, and hallways?
- What is the team’s approach to controlling noise and vibration from the HVAC systems?

Thermal Comfort

- What is the team’s approach to maintaining thermal comfort in the buildings they design?
- How much control will teachers have over their individual classrooms? Why is this method proposed?

Visual Comfort

- What is the team’s approach to ensuring visual comfort in the buildings they design?
- Do they have examples (preferably classrooms) that can be visited and “test driven”?

Daylighting

- What examples can the team provide of previous projects that incorporate daylighting?
- What daylighting strategies did the team use?
- Are the occupants satisfied with the results?
- Are the strategies saving energy? How much?
- What analysis tools does the team use to optimize performance of the daylighting systems it designs?

Safety and Security

- Does the team have experience with Crime Prevention Through Environmental Design (CPTED)?
- How has the team incorporated CPTED principles into previous projects (preferably schools)?
- How does the team balance the use of security technology and the use of CPTED principles in its buildings? Does it emphasize “security by design” first, and technology second?

Life-Cycle Cost Analysis

- Has a life-cycle cost analysis been included in the contract?
- What life-cycle cost methodology does the team use on its projects?
- How does it use the methodology to reduce the total ownership costs of the buildings it designs?
- Has it applied the methodology to school design? What were the results?
- What methodology does the team propose for the project under discussion?

Commissioning

- Have any of the team’s previous buildings gone through a commissioning process?
- How detailed was the commissioning? Who acted as commissioning agent?
- What were the results?

Energy Analysis Tools

- What energy analysis tools does the team use on its projects?
- How does it use these tools to reduce energy consumption in its designs?
- Has it applied the tools to school design? What were the results?
- What tools does the team propose for the project under discussion?

Energy-Efficient Building Shell

- How has the team provided energy efficient walls, floors, and roofs on previous projects?
- What key techniques, materials, and products were used, and what was the resulting impact on energy performance?
- Are the systems still performing as designed?

Environmentally Preferable Materials and Products

- What experience does the team have in specifying environmentally responsible materials and products in its projects?
- Does the team have experience specifying recycled content materials?
- Does the team have knowledge of how these materials and products can be procured, what delivery timelines can be expected, and how they are installed?
- Does the team have knowledge of how these materials and products perform over time?
- Has the team ever specified environmentally responsible materials and products for schools?

Waste Reduction

- Does the team have experience designing for materials efficiency?
- Has the team experience specifying construction waste management?

Environmentally Responsive Site Planning

- Does the team have experience creating environmentally responsive site plans?
- What were the key features, and how are they performing?

High Performance HVAC

- Does the team specify high performance HVAC systems as standard practice?
- What tools does the team use to analyze and optimize the performance of HVAC systems?
- What high performance HVAC systems has the team put in place in previous projects (preferably)
Appendix C: Discussion Guide

Using the Discussion Guide

- Are these systems providing a high-quality visual environment and saving energy?
- Have they applied any of these techniques to schools?
- What have been the results?

Renewable Energy

- What is the team’s experience designing and/or installing renewable energy systems?
- What specific systems have they used or installed (preferably in schools)?
- How much energy are these systems saving?
- Are they still performing as intended?

High Performance Electric Lighting

- Does the team have experience designing high performance electric lighting systems (preferably in schools)?
- What tools does the team use to analyze and optimize the combined performance of daylighting and electric lighting systems?

Water Efficiency

- What is the team’s experience with water-efficient landscaping, water use reduction techniques, and/or innovative wastewater treatment systems?
- How much energy are these systems saving?
Site Analysis

Superior Indoor Air Quality
✓ Is the site near any current or planned sources of outdoor pollution?
✓ What are the ambient outdoor air quality conditions and prevailing wind direction(s)?

Acoustic Comfort
✓ Are there major sources of noise near the site (for example, highways, industrial sites, or shopping areas)?
✓ Can the site be used to minimize the impacts of these noise sources (for example, through earth berms, setbacks, building orientation, etc.)?

Thermal Comfort
✓ Are there prevailing breezes that could be used to help naturally ventilate the building?

Visual Comfort
✓ Does the site provide special views that should be preserved?

Daylighting
✓ Does the site allow the building to be oriented on an east-west axis, maximizing southern exposure?
✓ How will site elements (for example, existing trees or adjacent buildings) affect the building’s access to sunlight?

Safety and Security
✓ Are there clear lines of sight to and from the school building from throughout the site?

Life-Cycle Cost Analysis
✓ N/A.

Commissioning
✓ N/A.

Energy Analysis Tools
✓ N/A.

Energy-Efficient Building Shell
✓ N/A.

Environmentally Preferable Materials and Products
✓ Are there materials on the site that can be used in the building project?
✓ Does the site naturally lend itself to the use of certain environmentally preferable materials?

Waste Reduction
✓ Can any of the materials on the site, especially if it is previously developed, be safely salvaged or reused in the new construction (landscaping materials, concrete, interior materials)?

Environmentally Responsive Site Planning
✓ Can existing natural areas or features on the site be preserved?
✓ Does the site lend itself to controlling stormwater runoff?
✓ Can areas of the site be restored?
✓ Can connections to nearby ecosystems be maintained?

What areas of the site could be used as “outdoor laboratories” for teaching?
✓ If the site has been previously developed, what are the opportunities for reuse of building/site materials?
✓ What toxin risks are present on, or near, the site?
✓ How many alternative transportation options are easily accessible from the site?
✓ Will pedestrians and individuals using bikes have safe access to the school?

High Performance HVAC
✓ N/A.

High Performance Electric Lighting
✓ N/A.

Water Efficiency
✓ Does the site lend itself to the use of high efficiency irrigation techniques?
✓ Can municipal-supplied, reclaimed water be used for irrigation? Does the community, parents, and school board support such a plan?
✓ Could the site accommodate on-site wastewater treatment? Who would be responsible for its maintenance and operation?

Renewable Energy
✓ Does the site have good solar access — for daylighting; active and passive solar heating; solar hot water; and/or photovoltaic systems?
✓ Could the site use wind power to generate electricity?
Schematic Design

Superior Indoor Air Quality

- Will the HVAC system being considered provide adequate ventilation, and how will the design team verify that these goals are being met?
- Does the basic layout of the school keep operable windows and air intake vents away from sources of exhaust (such as cars and buses)?
- Do the preliminary selected materials support superior indoor air quality by limiting VOCs and other off-gassed pollutants?
- Will extreme roof or surface temperatures adversely affect the performance of the HVAC system (including air intakes and duct design)?

Acoustic Comfort

- Develop appropriate acoustical criteria (e.g., reverberation time (RT), noise criteria (NC), sound transmission (STC)), for each space that is of concern.
- Does the basic design of the classrooms help or hinder good acoustics? In other words, does it reduce sound reverberation by means of sound-absorbing materials?
- Do any of the classrooms face sources of outside noise, such as playgrounds, roads, or equipment? If so, what measures are proposed to reduce the impact of this noise?
- Are any of the classrooms located next to sources of inside noise (music rooms, rooms that use amplified sound systems, etc.). If so, what measures are proposed to reduce the impact of this noise?
- Have preliminary noise control guidelines (e.g., air velocity, NC criteria, duct layout, equipment location, etc.) been submitted and reviewed by the design team?

Thermal Comfort

- Are windows and skylights being designed to minimize “hot spots” caused by direct sunlight?
- Are temperature controls being considered for each classroom?

Visual Comfort

- Are the basic daylighting and electric lighting designs being developed so that they provide illumination as uniformly as possible, using task or accent lighting as appropriate to meet specific needs?
- Are individual lighting designs being developed for individual room types? Do the designs vary, even within room type, depending on the amount of daylight the room will receive?
- Is the potential for glare being analyzed, and are the lighting/daylighting systems being designed to minimize it?
- Are the color and texture of wall, floor, and ceiling surfaces being taken into account in terms of their interaction with the lighting and their combined impact on the visual environment?

Day lighting

- What basic strategies are being considered for bringing daylight into the school, particularly the classrooms?
- What strategies are being considered to control unwanted heat gain and glare?
- What tools are being used to analyze the impact of any daylighting strategies on the electric lighting system, and on visual comfort and energy use?
- What are the preliminary results of these analyses?

Safety and Security

- How have Crime Prevention Through Environmental Design (CPTED) principles been applied during this phase of the process?
- Are opportunities for natural surveillance and access control being “designed in”?
- What security technologies are being considered? How do they reinforce and extend the impact of the school’s security-focused design features?

Life-Cycle Cost Analysis

- Has the life-cycle cost methodology selected for the project been used to compare and optimize alternative design strategies at least once (preferably several times) during this phase of the process?

Commissioning

- Is appropriate design documentation being collected by and/or delivered to the commissioning agent?
- Has a preliminary commissioning plan been developed?

Energy Analysis Tools

- Has the energy analysis tool(s) selected for the project been used to project energy consumption at least once (preferably several times) during this phase of design?
- Do the results meet or exceed the energy goal for the facility?

Energy-Efficient Building Shell

- What basic assemblies and configurations are being considered for the walls, floors, and roofs of the facility?
- What types of materials — glazing, shading, insulation, air barriers, structural materials, etc. — are being considered?
- How are trade-offs being analyzed (for example, between amounts of window versus wall, between one type of glazing versus another, etc.), and how will the overall performance of the shell as a whole be optimized?
- How are the impacts of thermal mass being factored in?
- Are light-colored surfaces, particularly roofing, being considered as a means to reduce heat gain?
- Are the proposed roof colors in compliance with local building requirements, and do they have the support of the community?

Environmentally Preferable Materials and Products

- What types of environmentally preferable materials and products are being considered and where will they be used?
- Are materials with post-consumer recycled content being considered?

Waste Reduction

- Does the basic design facilitate...
Using the Discussion Guide

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**Environmentally Responsive Site Planning**
- Will storage areas be designated in the design for the collection of these recyclables?
- Is the building, particularly the classroom wings, oriented in a predominantly east-west direction to facilitate access to daylight?
- Does the design preserve existing natural areas or features on the site?
- Does the design help control stormwater runoff?
- Does design restore areas of the site?
- Are connections to nearby ecosystems being maintained?
- Does the design minimize areas covered with impervious surfaces (such as parking lots, paved walkways, etc.)?
- Are there opportunities to replace any non-permeable surfaces with permeable surfaces?

**High Performance HVAC**
- What type of HVAC system is being considered for the school?
- Why is this system optimal from a comfort/energy performance standpoint?
- How are the interactions between the HVAC system and other key building systems (such as lighting, daylighting, acoustics, building shell) being analyzed and optimized?
- Is natural ventilation being considered? If so, are its potential impacts on HVAC performance being factored into the analysis process?
- Can the HVAC equipment be shaded with building or landscaping elements to reduce solar gain?
- Will the acoustics or air flow of the system adversely affect the learning environment?
- Have noise and vibration from mechanical equipment and air distribution systems been analyzed?
- Have drafts been eliminated?

**High Performance Electric Lighting**
- What electric lighting system is being proposed for the school and, in particular, for the classrooms?
- What are its energy and visual performance benefits?
- How does it interact with the daylighting strategies being used?
- How are these interactions being analyzed and optimized?
- Will the control systems perform as expected during both active and quiet classroom activities?

**Water Efficiency**
- Is water-efficient landscaping part of the preliminary site design?
- Is irrigating only the athletic fields, not plants near buildings or parking lots, being considered?
- Are water reduction techniques being considered for school plumbing fixtures and equipment?
- Are innovative wastewater treatment techniques being considered? Will any additional staff be needed to maintain or operate the systems?

**Renewable Energy**
- What renewable energy strategies are being considered for the school? Will any additional staff be needed to maintain or operate the systems?
- Are the systems as secure as possible to minimize the risk of vandalism?
- How much energy will they save?
- What are their life-cycle cost benefits?
- How will they impact the site plan or the building design?
- How will they impact other building systems (such as lighting, electrical, HVAC, building shell)?
Design Development
Superior Indoor Air Quality
✓ Will the HVAC system provide adequate ventilation, especially to the classrooms?
✓ Is the system designed to maintain the indoor relative humidity between 30% to 50%?
✓ Does the design provide local exhausts for restrooms, kitchens, science labs, janitor's closets, copy rooms, and vocational/industrial shop rooms? How are they controlled?
✓ Does the design include CO₂ sensors in large assembly areas to monitor air quality?
✓ Have cleaning products been identified that support good indoor air quality?
✓ What design elements have been included to facilitate integrated pest management to reduce the need for pesticides?

Acoustic Comfort
✓ How do the proposed materials and finishes, especially those used in the classrooms, contribute to reducing sound reverberation?
✓ Have the classrooms been analyzed in terms of projected acoustic performance and speech communication?
✓ Will the proposed heating, ventilating, air conditioning (HVAC) system for the classrooms create excessive noise? If so, how will the impacts of this noise be dealt with?
✓ Have the original acoustic criteria been utilized in analyzing the project?

Thermal Comfort
✓ Are HVAC distribution layouts designed to ensure all parts of a room receive adequate ventilation while eliminating drafts?

Visual Comfort
✓ Do the daylighting and electric lighting system designs provide illumination as uniformly as possible, using task or accent lighting as appropriate to meet specific needs?
✓ What tools have been used to model the interactions of both these systems in terms of their impacts on visual comfort?
✓ Have direct/indirect lighting fixtures been selected for general illumination in classrooms?
✓ What shading strategies (internal and external) have been selected?
✓ Have individual lighting designs been developed for individual room types? Do the designs vary, even within room type, depending on the amount of daylight the room will receive?
✓ Has the potential for glare been analyzed, and have the lighting/daylighting systems been designed to minimize it?
✓ Have the color and texture of wall, floor and ceiling surfaces been selected for general use in the classrooms? How are they controlled?
✓ Are the classrooms receiving as much daylight as possible, while avoiding glare and unwanted heat gain?
✓ What types of glazing have been selected for windows, clerestories, skylights, and/or roof monitors? How well do they match daylight and electric lighting systems interact?
✓ What analyses have been done to optimize these interactions?
✓ Will the combined daylighting/electric lighting strategies reduce energy use and lower the school's operating costs over time?
✓ Has the possibility of reducing the number of light fixtures, or the number of lamps, in daylit rooms been investigated?

Safety and Security
✓ How have Crime Prevention Through Environmental Design (CPTED) principles been applied during this phase of the process?
✓ Have opportunities for natural surveillance and access control been “designed in”?
✓ What security technologies have been selected? How do they reinforce and extend the impact of the school’s security-focused design features?

Life-Cycle Cost Analysis
✓ Has the life-cycle cost methodology selected for the project been used to compare and optimize alternative design strategies at least once (preferably several times) during this phase of the process?

Commissioning
✓ Is appropriate design documentation being collected by, or delivered to, the commissioning agent?
✓ Has a commissioning report been prepared?

Energy Analysis Tools
✓ Has the energy analysis tool(s) selected for the project been used to project energy consumption at least once (preferably several times) during this phase of design?
✓ Do the results meet or exceed the energy goal for the facility?

Energy Efficient Building Shell
✓ What basic wall, floor, and roof assemblies have been selected?
✓ What types of materials — glazing, shading, insulation, air barriers, structural materials — have been selected, and why are they better, from an energy and life-cycle cost perspective, than other alternatives?
✓ How have trade-offs been analyzed (between amounts of window versus wall, between one type of glazing versus another, etc.), and how has the performance of the building shell as a whole been optimized?
✓ Have the impacts of thermal mass been factored in?
✓ Are light-colored surfaces, particularly roofing, being used as a means to reduce heat gain?
Environmentally Preferable Materials and Products

- What types of environmentally preferable materials and products have been selected, and where will they be used? Have materials with post-consumer recycled content been selected?
- Are all the selected materials and products low emitters of indoor air contaminants?

Waste Reduction

- Does the final design facilitate recycling by students and faculty? How will the materials be stored?

Environmentally Responsive Site Planning

- Does the final design preserve existing natural areas or features on the site?
- Does final design restore areas of the site? How?
- Are connections to nearby ecosystems being maintained? How?
- Does the design help control stormwater runoff?
- Does the design minimize areas covered with impervious surfaces (such as parking lots, paved walkways, etc.)?
- Do landscaping strategies, particularly tree planting, enhance the building’s high performance features (for example, by providing shade where it’s needed but not blocking sunlight that’s used for daylighting)?

High Performance HVAC

- What type of HVAC system has been selected for the school?
- Why is this system optimal from a comfort/energy performance standpoint?
- Is it the best system from a life-cycle cost perspective?
- How have the interactions between the HVAC system and other key building systems (lighting, daylighting, building shell) been analyzed and optimized?
- Has natural ventilation been considered? If so, have its potential impacts on HVAC performance been factored into the analysis process?
- Has the HVAC equipment been “right sized” to meet predicted demand?
- What control system(s) has been selected, and how will it affect performance?
- What level of control will individual teachers have over the heating, ventilating, and air conditioning of their classrooms?
- Is the entire system configured for easy operation, maintenance, and repair?

High Performance Electric Lighting

- What electric lighting system(s) has been selected for the school and, in particular, for the classrooms?
- What are its energy and visual performance benefits?
- How does it interact with the daylighting strategies being used? How have these interactions been analyzed and optimized?
- Have fewer fixtures and/or lamps been specified for daylit spaces?
- What control system(s) has been selected, and how will it affect performance?
- What level of control will teachers have over the lighting in their classrooms?

Water Efficiency

- Has high efficiency irrigation technology been selected for athletic fields?
- Does the design use captured rainwater or recycled water for irrigation?
- Does the design include high efficiency equipment (dishwashers, laundry, cooling towers)?
- Does the design include low-flow showerheads and automatic lavatory faucet shut-off controls?
- Does the design include innovative wastewater treatment techniques?

Renewable Energy

- What renewable energy strategies have been selected and incorporated into the design?
- How much energy will they save?
- What are their life-cycle cost benefits?
- How do they impact other building systems (lighting, electrical, HVAC, building shell)?
- What analysis has been done to ensure that all these systems interact optimally?
**Construction Documents**

**Superior Indoor Air Quality**
- Has a construction IAQ plan been required? Is a flush out required? Has time been allocated in the construction time line for the proper flush out, and what measures have been taken to ensure that the contractors perform the flush out?
- Will the HVAC system as finally configured provide adequate ventilation, especially to the classrooms?
- Will the system maintain the indoor relative humidity between 30% to 50%?
- Are local exhausts with effective controls for restrooms, kitchens, science labs, janitor’s closets, copy rooms, and vocational/industrial shop rooms provided?
- Have CO₂ sensors to monitor air quality been included in large assembly areas?
- Are all the selected interior materials and products low emitters of indoor air contaminants?
- Have recessed grates or "walk-off" mats been installed at entrances to reduce the amount of dirt entering the building? What are the maintenance impacts?

**Acoustic Comfort**
- Are the walls and doors of classrooms that are located next to noise sources designed so that they minimize sound transmission?
- If rooftop HVAC equipment is being used, is it mounted on vibration isolators to reduce noise and vibration transmission?
- Have the original acoustic criteria been utilized in analyzing the project?

**Thermal Comfort**
- Do HVAC distribution layouts in their final configurations ensure all parts of a room receive adequate ventilation?
- Have controls been installed to provide teachers adequate control over the thermal comfort of their classrooms?

**Visual Comfort**
- Do the daylighting and electric lighting systems in their final configurations provide illumination as uniformly as possible, using task or accent lighting as appropriate to meet specific needs?
- Have direct/indirect lighting fixtures been specified for general illumination in classrooms?
- What shading strategies (internal and external) have been specified?
- Have the final configurations of other building components — like the color of the walls, floor, or ceiling — been changed in ways that might influence system performance? Have the potential impacts of these changes on visual comfort been accounted for?

**Daylighting**
- Will the construction details for the daylighting components (the windows, light shelves, roof monitors, skylights, shading devices, etc.) modify the performance of the system as a whole; that is, will the required amount of daylight still reach the classrooms, will glare and heat gain still be controlled, etc.? What will be the impact — on operating costs and on visual comfort — of any changes in performance?
- Will the final construction details of other building components (for example, the color and reflectance of roofing materials adjacent to skylights or roof monitors) change the dynamics of the daylighting system and impact performance? What will be the impact — on operating costs and on visual comfort — of any changes in performance?
- What measures have been taken to eliminate leaks from the daylighting systems?

**Safety and Security**
- What type of exterior lighting has been specified and how will it improve security?
- Have durable materials been specified in critical areas such as entrances?
- What security technologies have been specified? How do they reinforce and enhance the building’s security-focused design features?
- Have lens guards been specified in high activity areas like playgrounds, gyms, and fields?

**Life-Cycle Cost Analysis**
- Has the life-cycle cost methodology selected for the project been used to compare and optimize alternative design strategies at least once during this phase of the process?

**Commissioning**
- Have commissioning requirements been included in the construction documents?
- Has a written end-of-phase commissioning report been prepared?

**Energy Analysis Tools**
- Has the energy analysis tool(s) selected for the project been used to project energy consumption at least once during this phase of design?
- Do the results meet or exceed the energy goal for the facility?

**Energy-Efficient Building Shell**
- Do the final construction details for the wall, floor, and roof assemblies maintain the original design intent in terms of energy performance and sound isolation (for example, do the assemblies allow insulation to be installed at the thickness originally specified; do air barriers cover all the areas they are supposed to; can areas such as roof cavities that need ventilation be adequately vented in the current configuration, etc.)?

**Environmentally Preferable Materials and Products**
- Are the construction documents clear and explicit concerning the required environmental attributes of the materials and products specified?
- Is language included in the documents requiring that a proposed material or product substitution must be equal to, or better than, the specified product
in terms of its environmental attributes?

Waste Reduction
✓ Has a construction waste management plan been required? Are goals specified for waste reduction and for job-site recycling within the contract documents and specifications?

Environmentally Responsive Site Planning
✓ Have hardy, indigenous plants been specified in the landscaping plan?
✓ Have exterior lights been designed to focus downward to reduce light pollution of the night sky?
✓ Has the exterior lighting been designed with the neighborhood and community in mind?

High Performance HVAC
✓ Do the equipment and products specified for the HVAC system continue to meet the design and performance goals established previously?
✓ What analyses have been done to ensure the system is “right sized” for the expected demand? Will it handle both current and projected demand?

High Performance Electric Lighting
✓ What lamps, ballasts, and fixtures have been specified?
✓ Why are they the best choices in terms of visual comfort, energy use, and long term performance? What are the manufacturer’s warranties? What warranties can be expected for replacement products?
✓ Will the system as finally configured and specified be easy to operate, maintain, and repair?
✓ What is the impact of the system as finally configured on electricity use?
✓ Does the system as finally configured minimize waste heat generation? Has this been taken into account in sizing the cooling system?
✓ What controls have been specified? How will they help save energy and operating costs?
✓ What level of control will individual teachers have over the heating, ventilating, and air conditioning of their classrooms?

Water Efficiency
✓ N/A.

Renewable Energy
✓ Do the final construction details for the renewable energy systems allow the systems to perform as designed? (For example, are solar systems installed so that they face the right direction, at the correct angle, to receive the right amount of sunlight? Does the final location of another current or planned building component — like a rooftop air conditioner — prevent sunlight from reaching a solar collector?) Are the solar collectors as vandal-proof as possible?
✓ How are the renewable energy systems in their final configurations anticipated to perform from a life-cycle standpoint?
✓ What warranty periods have been specified for the systems? Who will service the system once the warranty has expired?
Appendix C: Discussion Guide Using the Discussion Guide

Bidding

Superior Indoor Air Quality
✔ Have any substitutions been proposed, such as alternative materials or a different ventilation system, that could impact indoor air quality?
✔ Are all substitute materials and their proposed cleaning agents low emitters of indoor contaminants?
✔ Do substitute materials require different cleaning processes that may contaminate indoor air?
✔ Are substitutions being proposed for materials or assemblies designed to act as barriers to sources of indoor contaminants? Will the substitute materials/assemblies also act as effective barriers?

Acoustic Comfort
✔ Have any substitutions been proposed, such as alternative wall/ceiling materials or different types of HVAC equipment, that could impact acoustical quality, particularly in the classrooms?
✔ If these substitutions are accepted, how will they impact the original acoustic criteria and overall acoustic comfort?

Thermal Comfort
✔ Have any substitutions been proposed, such as alternative glazing materials, different types of insulation, or different types of ventilation hardware, that could affect thermal comfort, especially in the classrooms?
✔ If these substitutions are accepted, how will they impact the thermal comfort of students and teachers, the energy performance of the building, and its life-cycle cost?

Visual Comfort
✔ Have any substitutions been proposed, such as alternative glazing materials, different types of lamps or light fixtures, or alternative colors for walls, floors, or ceilings, that could affect visual comfort, especially in the classrooms?
✔ If these substitutions are accepted, how will they impact the visual comfort of students and teachers, the energy performance of the building, and its life-cycle cost?

Daylighting
✔ Have any substitutions been proposed, such as alternative glazing materials or different types of shading, that could impact the intended performance of the daylighting system?
✔ If these substitutions are accepted, how will they impact system performance, visual comfort, and life-cycle cost?

Safety and Security
✔ Have any material substitutions been proposed that could reduce the durability — and increase the vulnerability — of critical areas in the building, such as entrances?
✔ Have any security technology substitutions been proposed?
✔ How well will the alternative technologies fit in with and complement the school's design-focused security measures?
✔ How will the substitute technologies interface with other controls systems in the school (for example, those for the lighting and HVAC systems)?
✔ If substitutions are accepted, will they be as easy to operate, maintain, and repair as the originally specified products and systems?

Life-Cycle Cost Analysis
✔ Is the life-cycle cost methodology selected for the project being used to analyze proposed material or product substitutions in terms of their impacts on overall performance and cost effectiveness?

Commissioning
✔ Has the commissioning plan been clearly described to potential bidders?

Energy Analysis Tools
✔ Is the energy analysis tool(s) selected for the project being used to evaluate the energy consumption consequences of proposed materials, products, or system substitutions?

Do the substitutions impact the school's ability to meet its energy goal for the facility?

Energy-Efficient Building Shell
✔ Have any substitutions been proposed, such as alternative glazing materials, different types of insulation, or alternative roofing products, that could impact the intended performance of the building shell?
✔ If these substitutions are accepted, how will they impact the energy performance of the building and its life-cycle cost?

Environmentally Preferable Materials and Products
✔ Are all proposed substitutions equal to, or better than, the specified products in terms of environmental attributes?
✔ Are the substitutions also functionally equivalent to the specified products? (In other words, if they are accepted, they will not adversely affect the performance of the system or assembly in which they are used.)
✔ What analyses have been done to ensure substitutions will not degrade environmental quality or system performance?

Waste Reduction
✔ Has a construction waste management plan that satisfies the goals of the project been submitted?

Environmentally Responsive Site Planning
✔ Have any substitutions been proposed, such as different plants, alternative materials for parking lots or walkways, or alternative exterior light fixtures, that could reduce the environmental quality of the site plan?
✔ Will any of these substitutions impact the performance of the building (for example, fewer trees may mean less shade and more heat gain in daylit classrooms)?
✔ Have these impacts been analyzed? How will they affect the overall life-cycle cost of the facility?

High Performance HVAC
✔ Have any substitutions been
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High Performance Electric Lighting
✓ Have any substitutions been proposed, such as alternative lamps, ballasts, or controls, that could impact the intended performance of the electric lighting system?
✓ Will these substitutions provide the same level of visual comfort as the design calls for?
✓ Will they add any additional waste heat to the space?
✓ Will they work correctly with the specified control system?
✓ If these substitutions are accepted, how will they impact visual comfort, energy performance, and life-cycle cost?

Water Efficiency
✓ Have any substitutions been proposed, such as alternative plumbing fixtures, different types of landscape vegetation, or an alternative irrigation system, that could reduce the school’s water efficiency?
✓ If these substitutions are accepted, how will they impact water use and overall life-cycle costs at the facility?

Renewable Energy
✓ Have any substitutions been proposed to specific systems or to the materials from which the systems are constructed that could impact intended performance?
✓ If these substitutions are accepted, how will they impact the energy performance and life-cycle cost of the whole facility?
Appendix C: Discussion Guide Using the Discussion Guide

Construction Administration

Superior Indoor Air Quality

✓ Is the impact of the construction process on indoor air quality — for workers and, in the case of renovations, for students and teachers — being managed?
✓ Is the building being constructed as designed to ensure high indoor air quality?
✓ Have any substitutions been proposed, such as alternative materials or a different ventilation system, that could impact indoor air quality?
✓ Are all substitute materials and their cleaning agents low emitters of indoor contaminants?
✓ Do substitute materials require different cleaning processes that may contaminate indoor air?
✓ Are substitutions being proposed for materials or assemblies designed to act as barriers to sources of indoor contaminants? Will the substitute materials/assemble also act as effective barriers?
✓ Is there a plan to “flush out” the facility for at least 72 hours after construction and before occupancy?

Acoustic Comfort

✓ Is the building being constructed as designed to achieve acoustic comfort?
✓ Have any substitutions been proposed, such as alternative wall/floor/ceiling materials or different types of HVAC equipment, that could impact the original acoustic criteria and acoustical quality, particularly in the classrooms?
✓ If these substitutions are accepted, how will they impact overall acoustic comfort?
✓ Has the acoustical consultant performed any site visits?

Thermal Comfort

✓ Is the building being constructed as designed for optimal thermal comfort, especially in the classrooms?
✓ Have any substitutions been proposed, such as alternative glazing materials, different types of insulation, or different types of ventilation hardware, that could affect thermal comfort, especially in the classrooms?
✓ If these substitutions are accepted, how will they impact the thermal comfort of students and teachers, the energy performance of the building, and its life-cycle cost?

Visual Comfort

✓ Is the building being constructed as designed to enhance visual comfort, especially in the classrooms?
✓ Have any substitutions been proposed, such as alternative glazing materials, different types of lamps or light fixtures, or alternative colors for walls, floors, or ceilings, that could affect visual comfort, especially in the classrooms?
✓ If these substitutions are accepted, how will they impact the visual comfort of students and teachers, the energy performance of the building, and its life-cycle cost?

Daylighting

✓ Is the building, especially the classrooms, being constructed as designed to provide the appropriate or intended levels of natural light?
✓ Have any substitutions been proposed, such as alternative glazing materials or different types of shading, that could impact the intended performance of the daylighting system?
✓ If these substitutions are accepted, how will they impact system performance, visual comfort, and life-cycle cost?
✓ Have the controls been properly installed and commissioned?

Safety and Security

✓ Is the building being constructed as designed to improve security?
✓ Are security technologies being installed as designed?
✓ Have any material substitutions been proposed that could reduce the durability — and increase the vulnerability — of critical areas in the building such as entrances?
✓ Have any security technology substitutions been proposed?
✓ How well will the alternative technologies fit in with and complement the school’s design-focused security measures?
✓ How will the substitute technologies interface with other controls systems in the school (for example, those for the lighting and HVAC systems)?
✓ If substitutions are accepted, will they be as easy to operate, maintain, and repair as the originally specified products and systems?

Life-Cycle Cost Analysis

✓ Is the life-cycle cost methodology selected for the project being used to analyze proposed material or product substitutions in terms of their impacts on overall performance and cost effectiveness?

Commissioning

✓ Has the commissioning plan been implemented?
✓ Has the functional performance of key systems been tested and verified?
✓ Are the results documented in a commissioning report?
✓ Have appropriate school staff been trained concerning proper operation of system equipment and controls?

Energy Analysis Tools

✓ Is the energy analysis tool(s) selected for the project being used to evaluate the energy consumption consequences of proposed materials, products, or system substitutions?
✓ Do the substitutions impact the school’s ability to meet its energy goal for the facility?

Energy-Efficient Building Shell

✓ Is the building shell being constructed as designed to achieve a high level of energy efficiency?
✓ Have any substitutions been proposed, such as alternative glazing materials, different types
of insulation, or alternative roofing products, that could impact the intended performance of the building shell?

✓ If these substitutions are accepted, how will they impact the energy performance of the building and its life-cycle cost?

Environmentally Preferable Materials and Products

✓ Is the building being constructed using the environmentally preferable products specified?

✓ Are all proposed substitutions equal to, or better than, the specified products in terms of environmental attributes?

✓ Are the substitutions also functionally equivalent to the specified products? (In other words, if they are accepted they will not adversely affect the performance of the system or assembly in which they are used.)

✓ What analyses have been done to ensure substitutions will not degrade environmental quality or system performance?

Waste Reduction

✓ Is the construction waste management plan being carried out?

✓ Are efforts being made to minimize construction waste?

✓ Is some percentage of demolition and/or land-clearing waste being salvaged or recycled?

Environmentally Responsive Site Planning

✓ Is the site being constructed and landscaped in the environmentally responsive way it was designed?

✓ Have any substitutions been proposed, such as different plants, alternative materials for parking lots or walkways, or alternative exterior light fixtures, that could reduce the environmental quality of the site plan?

✓ Will any of these substitutions impact the performance of the building (for example, fewer trees may mean less shade and more heat gain in daylit classrooms)?

✓ Have these impacts been analyzed? How will they affect the overall life-cycle cost of the facility?

High Performance HVAC

✓ Is the HVAC system being installed as designed to achieve high performance?

✓ Have any substitutions been proposed, such as alternative equipment, different types of controls, or alternative delivery hardware (for example, diffusers), that could modify system performance?

✓ After the substitutions, will the system still be “right sized” to meet the demand (not over or undersized)?

✓ If these substitutions are accepted, how will they impact the energy performance of the building and its life-cycle cost?

Water Efficiency

✓ Are the building and grounds being constructed as designed to conserve water?

✓ Have any substitutions been proposed, such as alternative plumbing fixtures, different types of landscape vegetation, or an alternative irrigation system, that could reduce the water efficiency of the school?

✓ If these substitutions are accepted, how will they impact water use and overall life-cycle costs at the facility?

Renewable Energy

✓ Are the renewable energy systems being installed as designed to achieve high performance?

✓ Have any substitutions been proposed — to specific systems or to the materials from which the systems are constructed — that could impact intended performance?