

**Characterization of Guidance Documents for Creating High
Performance Schools**

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February, 2002
Qualifying Paper
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Executive Summary

School systems across the U.S. are struggling to build new schools and renovate aging ones to accommodate increasing enrollments and new technologies. Given the high cost of new construction as well as the costs of operating, maintaining and retrofitting the current, declining building stock, many school systems are recognizing the benefits of high performance schools. The term “high performance”, often used interchangeably with “sustainable” and “green”, is used to describe schools that minimize environmental harm, maximize the performance of facilities, cost less over the life of the building, and create educational environments that are optimal for learning.

As school systems seek to improve the performance of their facilities and reduce costs, they are relying on (or creating) a variety of guides to assist them with design, construction, and operation/maintenance. Intended to educate stakeholders about the concepts of high performance facilities, these documents are important vehicles for implementing research in sustainability, school design, environment and behavior, and related fields. However, to date, there have been no reviews of the guidance documents to examine their focus and content.

This paper characterizes nine guidance documents that may be used by schools to create high performance facilities. The documents reviewed include: the Poudre School District (CO) [PSD], *Sustainable Design Guidelines*; the Collaborative for High Performance Schools, *Best Practices Manual, Volumes I, II and III* [CHPS]; Innovative Design, *Sustainable Schools* [ID]; Partnership for Resource Efficient Schools (Seattle), *Recommended Best Practices Manual* [SPS]; Triangle J. Council of Governments (NC), *High Performance Guidelines: Triangle Region Public Facilities* [TJCoG]; U.S. Green Building Council, *Leadership in Energy and Environmental Design (LEED™) Green Building Rating System* and the *LEED™ Reference Guide* [LEED]; Commonwealth of Pennsylvania, *Guidelines for Creating High Performance Green Buildings* [PA]; City of New York, *High Performance Building Guidelines* [NYC]; and, *Minnesota Sustainable Design Guide* [MN].

Each of the nine guidance documents were evaluated in terms of each of the following:

- 1) Goals
- 2) Organizational structure
- 3) Stakeholders intended to use the guidance documents (a.k.a. target audience)
- 4) Building life cycle phases addressed
- 5) Physical environmental conditions addressed

Goals

The nine guidance documents have similar goals. These have been combined into the following list:

- Illustrate high performance design strategies
- Encourage/inspire change to create high performance buildings
- Inform/educate stakeholders

- Provide a framework/roadmap for design and construction
- Help professionals exercise due diligence
- Facilitate input from stakeholders
- Help stakeholders understand their roles in the process
- Provide flexibility for setting priorities and measuring outcomes

A review of the definitions and attributes of high performance schools from these nine documents and other sources resulted in the following list of anticipated outcomes as well as important process and design considerations with respect to high performance schools.

Anticipated Outcomes of High Performance Schools	
<ul style="list-style-type: none"> • Societal impacts <ul style="list-style-type: none"> ○ Resource conservation ○ Environmental protection ○ Building as a community resource • Building operation and maintenance <ul style="list-style-type: none"> ○ Ease of operation/maintenance ○ Reduced liability ○ Lower life cycle costs ○ Adaptable facility 	<ul style="list-style-type: none"> • Health and comfort <ul style="list-style-type: none"> ○ Indoor air quality ○ Thermal comfort ○ Visual comfort ○ Acoustical comfort • Teaching and learning <ul style="list-style-type: none"> ○ Teacher retention ○ Higher test scores ○ Improved attendance ○ Ecological literacy/building as a teaching tool • Safety and security

Considerations of High Performance Schools	
<i>Process Considerations</i>	<i>Design Considerations</i>
<ul style="list-style-type: none"> • Integrated design/collaborative team approach • Building commissioning • Community involvement • Feedback and data collection • Recycling and waste reduction 	<ul style="list-style-type: none"> • Sustainable sites and landscapes • Minimization of east-west exposure • Renewable energy sources • Efficient systems <ul style="list-style-type: none"> ○ Lighting ○ Mechanical ○ Shell ○ Water (including gray water) • Day lighting • Materials <ul style="list-style-type: none"> ○ Environmentally sensitive ○ Local • Transportation options (e.g., pedestrian and bike ways, near public transit) • Mimic nature • Opportunities to interact with nature • Appropriate technologies • Computer systems for monitoring • Storm water management

Organizational Structure

Although the goals of the guidance documents are similar, there are various approaches to organizing and presenting information. Four broad organizational categories were identified in this evaluation. These categories include:

- Building life cycle phases/processes (e.g., design, construction, commissioning)
- Building systems (e.g., HVAC, windows)
- Topics (e.g., water, site, financing)
- Physical environmental conditions (e.g., acoustics, thermal comfort)

The major headings and subheadings were reviewed to identify whether or not they address these categories (and their sub-categories) listed above. Several documents, including PSD, PA and NYC separate processes (e.g., charrettes) from technical information (e.g., water management, renewable energy). It is interesting to note that two of these (PSD, PA) include some design-related processes (e.g., site design) with the more technical information, while other non-design types of processes are addressed under a separate category. For example, PSD categorizes project management and procurement under “The Sustainable Design Process”, while site planning, landscape design and commissioning are categorized under the heading “The Sustainable Design Product: Eleven Features of Sustainable Schools” heading, even though these too are processes. In the PA document, green team building and goal setting are included under the heading “Green Design Systems” rather than “Green Design Process”.

The CHPS, LEED™, TJCoG and NYC documents all contain five of the same topic areas listed as major headings, although they may be given slightly different names. These include, site, energy, water, materials, and indoor environment.

Intended Readers

Each guidance document is intended for multiple types of readers from various stakeholder groups. However, they are not organized according to the specific stakeholders addressed. Therefore, each stakeholder identified may need to read the entire document to identify relevant sections. The NYC document, however, is one exception. It does clearly specify which sections of the document pertain to specific stakeholders by using a matrix and icons near the front of the document. The documents that include building life cycle phases in the headings or subheadings, such as PA and MN, may facilitate their use by specific stakeholders involved in various building phases. The MN design guide specifies action items for each building life cycle phase with each recommended facility strategy so that contributing stakeholders can address those issues. Most of the documents reviewed primarily focus on the design team, while providing a minimal number of recommendations for the construction team and facilities personnel. There is typically very little information intended for other members of an extended project team, such as occupants or representatives from the local community. The majority of the documents call for a shift from the traditional, linear approach to facility design and delivery to an integrated team approach where key stakeholders work together from the beginning of the process to ensure that sustainability goals are met. The team

may consist of many stakeholders, possibly including the owner, future users/occupants, building manager, architects, engineers, consultants, construction managers, contractors, subcontractors, suppliers, government agencies, members of the local community and others.

Building Life Cycle Phases

Each guidance document addresses each of the four major building life cycle phases (planning and pre-design, design, construction and operation/maintenance) to some degree, with the exception of PSD, that does not address operation/maintenance. The vast majority of recommendations and strategies are best addressed in the design phase. There are fewer recommendations for the construction and operation/maintenance phases. One example includes “Develop and follow a construction waste management plan...” (TJCoG). Several documents include construction-related strategies that address waste management issues, but ignore a wide variety of other strategies that could be included, such as duct sealing (e.g., use mastic to seal ductwork). Of the documents reviewed, the MN and SPS documents provide the most information for the operation/maintenance phase. The MN document includes action items for appropriate life cycle phases with each recommended strategy. For each chapter, the NYC document includes a list of deliverables to be obtained during applicable life cycle phases.

Physical Environmental Conditions

Each guidance document was reviewed to identify whether or not it addresses fifteen physical variables, each having been shown in the literature to have some impact on student learning or behavior. Of these, seven conditions were addressed by the majority of the guidance documents reviewed. These include electric lighting, daylighting, interior finishes, acoustics, temperature, relative humidity, and indoor air quality. Other variables, such as privacy amenities, interior spaciousness, furniture type and arrangement, classroom adaptability, open versus closed classrooms, and safety and security receive little or no attention in the high performance guidelines.

This study has shown that a wide variety of guidance documents exist to help facility decision-makers create high performance buildings. The organizational structures, the breadth and depth of the information, the types of benefits that are reported, the specific stakeholders addressed, the building life cycle phases addressed, and other factors likely contribute to whether or not these documents are effective in providing the right information to the right stakeholders in the right format. This, in turn, may impact whether or not school districts are successful at adopting the procedures and strategies to deliver high performance facilities. There is a need for additional research to help answer these questions.

Characterization of Guidance Documents for Creating High Performance Schools

Abstract

The United States is facing a problem of aging, deteriorating, inefficient schools. One proposed solution is to design and construct high performance schools, also called green or sustainable schools. The paper presents the findings of an evaluation of nine guidance documents that may be used to assist school districts with creating high performance facilities. With some exceptions, these guidance documents may not adequately address the larger set of stakeholders likely to be involved with the integrated, high performance design process. The planning and design phases of the building life cycle are given much more attention than the construction and operation/maintenance phases of the building life cycle. There is a need for research on guidance documents to test whether or not they are accurate, appropriate and effective, and whether various organizational structures impact comprehension by members of their intended target audience. There is also a need to develop information that is appropriate for all stakeholders throughout the building life cycle, and to create tools for evaluating the performance of facilities after they are occupied.

1.0 Introduction

School systems across the U.S. are struggling to build new schools and renovate aging ones to accommodate increasing enrollments and new technologies. Given the high cost of new construction as well as the costs of operating, maintaining and retrofitting the current, declining building stock, many school systems are recognizing the benefits of high performance schools. High performance schools are designed, constructed and maintained to be resource-efficient, healthy, comfortable, safe, secure, adaptable, and easy to operate and maintain. They cost less to operate and create environments that enhance learning (CHPS 2001). Additionally, high performance schools reduce adverse impacts resulting from the construction and operation of built facilities on the natural environment.

As school systems seek to improve the performance of their facilities and reduce costs, they are relying on (or creating) a variety of guides to assist them with design, construction and operation/maintenance. These documents are often region-specific and reflect the priorities of the authoring agency, but they may also be appropriate for other regions and used by school systems across the country. Intended to educate stakeholders about the concepts of high performance facilities, these documents are important vehicles for implementing research in sustainability, school design, environment and behavior, and related fields. However, to date, there have been no reviews of the guidance documents to examine their focus and content. Without a doubt, those involved with the development of these guidance documents have reviewed similar documents when developing their guides, however, this information has not been published. Also, these reviews were conducted for the purpose of developing a guidance document, rather than for identifying additional opportunities for providing information to stakeholders. This paper characterizes nine guidance documents that may be used by schools to create high

performance facilities. This detailed analysis of the definitions, organizational structure, and content of these documents reveals that there are opportunities provide additional information that may help school systems adopt high performance practices at a more rapid rate.

Section 1 is the introduction. Section 2 describes some of the challenges currently facing school systems in the U.S., Section 3 presents high performance schools as a proposed solution, and Section 4 describes the methodology used in this evaluation. Section 5 contains the results of the evaluation and Sections 6 and 7 contain the conclusions and future research needs.

2.0 School Facility Challenges

Among the many factors that affect the abilities of students to learn and succeed, the condition of the facilities in which learning occurs, including interior environmental conditions, has been shown to contribute to or hinder learning (Bowers and Burkett 1987; Cash 1993; Chan 1980; Christie and Glickman 1980; Edwards 1991; Evans and Maxwell 1997; Heschong Mahone Group 1999; Wollin and Montagne 1981). Those who make decisions about school facilities – which schools to renovate, where to build new schools, what school designs to use and how to maintain the facilities – therefore play an important role in student education.

Unfortunately, the condition of many schools in the United States is less than desirable. The average age of school facilities in the U.S. is 42 years (Rowand 1999), many needing major renovations. Approximately \$127 billion is needed to bring schools up to good overall condition (Lewis et al. 2000). According to Lewis, when surveyed about satisfaction with environmental conditions, including lighting, heating, ventilation, indoor air quality, acoustics or noise control, and physical security of buildings, 43% of the schools responding reported at least one environmental factor as being unsatisfactory. Nearly one third of schools surveyed reported inadequate condition of heating, ventilation and air conditioning systems. Increasing enrollment and a push for smaller class sizes is creating a greater need for school construction and renovation.

The poor conditions that exist may hinder student achievement. Several studies have shown correlations between physical environmental conditions (e.g., lighting, humidity, acoustics) and student performance and/or behavior. In a study involving 47 small, rural high schools in Virginia, student achievement was shown to be higher in schools with better physical conditions (Cash 1993). Socioeconomic status was controlled. Higher science scores were associated with schools with better science laboratory facilities, and structural conditions had less of an impact on student achievement than cosmetic conditions. In another study involving 280 fourth and sixth grade students, those attending a newer school had higher achievement in math, reading, listening and language than those enrolled in an older, “less desirable” facility (Bowers and Burkett 1987)¹. Bowers also found that fewer major health problems were reported, fewer disciplinary actions were taken, and attendance was higher in the new school. The actual

¹ The specific scores used to evaluate achievement in this study were not specified.

extent to which physical features impact the learning process remains unclear, but occupants in school buildings perceive that features such as physical comfort and health and classroom adaptability affect educational outcomes (Lackney 1996). Realizing that school conditions impact student learning and behavior, many school systems are seeking to create high performance facilities to provide optimal learning environments.

One particular lighting study has received a great deal of attention. The Heschong Mahone Group (1999) studied the effects of daylighting on student performance. Test scores in math and reading were compared for 21,000 students from 3 school districts, including Orange Co., CA, Seattle, WA, and Fort Collins, CO to measure achievement. These scores were evaluated against lighting variables such as window size, tint, presence and type of skylights, and the amount of anticipated daylight. Multivariate linear regression was used to control for other factors such as demographics and participation in special programs. Students with more daylighting progressed 20% faster on math tests and 26% on reading tests in one year (data for the entire sample on 'progress' were not available). Those with the greater window area progressed 15% faster in math and 23% faster in reading than those with the least, and well designed skylights that diffuse light effectively were also related to more rapid progress on test scores. Additionally, students in classrooms in which the windows are operable also progressed more quickly than those with inoperable windows.

Student behavior was the focus of a study that compared white walls and cool-white fluorescent lighting, common in school facilities, with blue walls and full-spectrum lighting (Grandgaard 1995). Off-task behavior and mean blood pressure were measured for five 6-year old boys and six 6-year old girls in a public school during 3 phases of the study (before modification, during and after the classroom was returned to its original condition). A decrease of 22% in off-task behaviors was observed in the room with the blue walls and full-spectrum lighting and student mean blood pressure was 9% lower.

According to Evans and Maxwell (1997) , associations between reading ability and noise exposure in elementary school children have been shown in multiple studies. In the ir study, 116 first and second grade students in two elementary, predominantly Black schools in New York City were evaluated to determine if language acquisition acts as a mediator between noise exposure and reading deficits, and whether short or long-term exposure contributes to reading problems. Chronic noise exposure was correlated with reading deficits, rather than acute exposure. Speech perception, rather than sound perception, acts as a partial mediator.

Christie and Glickman (1980) evaluated 156 students who were asked to perform 60 visually presented tasks from the Standard Progressive Matrices (a type of intelligence test), 1938 version, , in either a noisy environment (70 dbA) or a quiet environment (40 dbA). The findings indicate that boys perform complicated problems better in a noisy environment, while girls perform higher in a quiet environment.

Lighting impacts on student behavior was the focus of a study by Ott (1976). The behaviors of first-grade children in 4 windowless classrooms were observed. Standard

cool-white fluorescent lighting with solid plastic diffusers provided illumination in two of the classrooms, while the others used full-spectrum fluorescent tubes with lead foil to shield the ends of the tubes to reduce X radiation exposure. Children in the room with standard lighting were more fidgety and were observed “leaping from their seats, flailing their arms, and paying little attention to their teachers”, while those with full-spectrum lighting were less nervous and paid more attention to the teacher.

Green (1974) reviewed 3 studies that examined the relationship between relative humidity and absenteeism. The two studies involving schools showed reduced absenteeism when humidification was supplied during the heating season.

These and other studies are summarized in tabular form in Appendix A.

3.0 A Proposed Solution: High Performance Schools

One proposed solution to the problems facing school facilities is to design and construct high performance schools, also called green or sustainable schools. Although these terms do not necessarily have the same meaning, practitioners often use them interchangeably and define them similarly. These terms will also be used interchangeably in this paper to reflect the wording of the authors being cited. The terms high performance, sustainable and green are used to describe schools that minimize environmental harm, maximize the performance of facilities, cost less over the life of the building, and create educational environments that are optimal for learning.

School districts do not typically pursue high performance design merely to be good stewards of the natural environment. There is convincing evidence of multiple benefits from using high performance, green design. School systems, like other public and private organizations, are becoming increasingly aware that design and construction strategies that reduce harmful impacts on the natural environment also contribute to creating a more productive and economically feasible facility. Case studies of schools (some included in Appendix B) provide evidence of these benefits. In this day of increasing school enrollment and tight construction budgets, cost savings are often used to justify high performance design. The Sustainable Building Industry Council (SBIC) estimates that 30-40% savings can be achieved by school districts on utilities if sustainable design and construction practices are utilized for new schools. Approximately 20-30% can be saved on renovated buildings (SBIC 2001). Also, the SBIC estimates savings of \$500,000 over a 10-year period for the average middle school that utilizes daylighting strategies (Reicher 2000). Gary Bailey of Innovative Design, an expert in high performance school design, says that an average middle school could expect approximately \$100,000 a year in energy savings through green design (Tremain 1999).

In addition to cost savings, high performance strategies such as daylighting, improved thermal comfort, better indoor air quality, and increased interaction with the natural environment are believed to enhance learning, provide a valuable community resource, and minimize adverse impacts on the environment.

Those who pursue high performance design and construction have common goals, such as environmental protection, eco-education, and superior building performance. “Ecologically friendly” is considered one of the top ten facility design and planning solutions for school facilities today (Kennedy 2001b). Principles of sustainable design are incorporated to teach resource conservation, reduce resource use, and to enhance the learning environment. Bill Dierorff, business manager for the North Clackamas School District in Oregon, said of a project designed with natural ventilation, daylighting and other resource efficient strategies, “It is not our goal to be a green building. It is not our goal to be an energy-efficient building. Our goal is to be an educational facility and be the best educational facility we can be. Green buildings, energy efficient buildings, are strategies to reach that goal” (Ohrenschall 1999).

4.0 Methodology

With so much available information regarding high performance, green design, where does one begin? Schools across the U.S. have used various design guides and other guidance documents to assist them with these efforts. Each of the nine high performance guidance documents evaluated in this study (Table 1) were developed in the U.S. They have been selected for evaluation because each document was either:

1. Written specifically for use by schools, or;
2. Referenced by other documents or web sites addressing high performance schools.

The one document reviewed that does not meet either of these criteria is the *Minnesota Sustainable Design Guide*, selected because of its unique organizational structure that includes recommended actions for most phases of the building life cycle for each high-performance strategy included in the document.

The nine guidance documents were evaluated in terms of each of the following:

1. Goals
2. Organizational structure
3. Intended readers of the guidance documents
4. Building life cycle phases addressed
5. Physical environmental conditions addressed

Table 1 provides a listing of guidance documents evaluated² that may be used by schools to help them achieve their high performance goals, although not all of them were developed specifically for school facilities.

² Each of these guidance documents is available for free download. The 280 page LEED Reference Guide is the supporting document for the LEED Green Building Rating System. This document may be purchased (\$250 for members, \$400 for non-members) from the U.S. Green Building Council.

Table 1. High Performance/Sustainable/Green Schools Guidance Documents

Title	Author/Publisher	Availability
Sustainable Design Guidelines	The Poudre School District, CO (Unger, Forrest et al. 2000)	http://www.psd.k12.co.us/district/construction/
Best Practices Manual, Volumes I, II and III	Collaborative for High Performance Schools, CA (Collaborative for High Performance Schools 2001)	www.CHPS.net Free online. Printed copy available for \$30. A CD can also be ordered.r
Sustainable Schools	Innovative Design (Innovative Design 2001)	www.innovativedesign.net
Partnership for Resource-Efficient Schools, Recommended Best Management Practices	City of Seattle and Seattle Public Schools, WA	www.ci.seattle.wa.us/util/rescons/susbuid/docs/Resource.PDF
High Performance Guidelines: Triangle Region Public Facilities	Triangle J Council of Governments, NC (2001)(Triangle J Council of Governments 2001)	www.tjcog.dst.nc.us/hpgrpf.htm
Leadership in Energy and Environmental Design (LEED) Green Building Rating System	U.S. Green Building Council (U.S. Green Building Council 2000)	www.usgbc.org
Commonwealth of Pennsylvania Guidelines for Creating High Performance Green Buildings	Commonwealth of Pennsylvania, PA (Kobet and Powers 1999)	www.gggc.state.pa.us/publicitn/gbguides.html
High Performance Building Guidelines	City of New York, NY (City of New York 1999)	www.ci.nyc.ny.us/nyclink/html/ddc/home.html
Minnesota Sustainable Design Guide	University of Minnesota (2000)	www.sustainabledesignguide.umn.edu

5.0 Guidance Document Evaluation

The following section presents the findings of the evaluation of these high performance guidance documents. Sections 5.1 and 5.2 present an overview and the goals of each document. Sections 5.3 through 5.5 characterize the documents in greater detail.

5.1 Overview of Each Guidance Document

Poudre School District, CO: *Sustainable Design Guidelines* (approximately 60 pages)

This guidance document was written by the Superintendent of Schools, Assistant Superintendent of Business Services, Director of Facilities, and the District Architect (at the time of the writing) with the help of The Brendle Group. It includes information on the “new” procedural approach to school design in Poudre County as well as specific recommendations for incorporating eleven features of sustainable schools into their facilities. Case studies are scattered throughout, and a directory of other tools and resources is provided. There is no associated building rating tool, so specific performance criteria are not included. LEED will be used by the school district for comparing design proposals and for identifying other sustainable design opportunities. LEED certification may be sought for some projects. The school district’s “green team” has conducted research on specific products (e.g., Rastra panels, Armstrong recycled content ceiling tiles) and provides information in the document pertaining to those it considers as having potential for use within the district. Unique to this document is a section that matches Colorado model content standards for science with sustainable strategies to encourage using the building as a teaching tool.

Collaborative for High Performance Schools, CA: *Best Practices Manual* (greater than 500 pages)

The Collaborative for High Performance Schools (CHPS), established in 1999, is made up of utility, government and non-profit organizations. Multiple authors contributed to writing the manual and it is intended for use in the state of California. This three-volume manual is perhaps the most comprehensive of all the documents reviewed. Although it is large, when accessed electronically, bookmarks make it simple to navigate to the sections of interest to the user. *Volume I - Planning* contains information about procedural issues and benefits of high performance design. The discussion guide, to be consulted prior to each stage in the building process, provides questions to help the design team frame discussions so that each of fifteen elements of high performance schools is addressed. Three case studies are also included in Volume I. *Volume II - Design* includes more technical information aimed primarily at architects and engineers. The guidelines for specific products and strategies (e.g., bamboo flooring, central toplighting) include a recommendation, description, discussion of applicability, applicable codes, integrated design implications, costs, benefits, design tools, design details, operation/maintenance, commissioning, and examples and references, where appropriate. *Volume III – Eligibility Criteria* is a rating system that contains the performance criteria and documentation requirements for eligibility for becoming a CHPS school.

Innovative Design: *Sustainable Schools* (approximately 60 pages)

This document was developed by Innovative Design, a North Carolina based architectural firm, with technical assistance from Padia Consulting, BuildingGreen and the Sustainable Buildings Industry Council. It is the only document reviewed that organizes information

on the basis of goals of sustainable design: reducing operating costs; buildings that teach sustainability; improving academic performance; protecting our environment; designing for health, safety and comfort; and supporting community values. Using this approach, design recommendations may be included in more than one location. For example, several water conservation strategies are found in the section “reducing operating costs” and also “protecting our environment”.

Partnership for Resource-Efficient Schools, City of Seattle and Seattle Public Schools: Recommended Best Management Practices Promoting Energy Efficiency, Resource Conservation and Environmental Quality (approximately 170 pages)

The document was developed by team members from the city of Seattle, Seattle Public Schools and consultants. Following general information, there are three primary sections. Section I addresses the design phase, Section II the build-out phase and Section III the operation/maintenance phase. The appendices make up the remainder of the document. Sections I-III are written as stand-alone documents. The design section includes strategies for incorporating resource-efficient strategies into building design, many of which can be implemented with minimal effort. Sections II and III are similar in that they also provide a menu-type checklist of strategies that can be implemented.

Triangle J Council of Governments, NC: High Performance Guidelines: Triangle Region Public Facilities, Version 1.0 (approximately 150 pages)

The guidelines were developed by a team of people, with more than 50 professionals contributing, and the document is intended for use by local governments and schools in the service area of the Triangle J Council of Governments. The guidelines were modeled after the LEED Green Building Rating System, version 2.0. Like LEED, there is an associated point system, and a building can qualify as high performance at one of four levels when specified numbers of points are earned. The guidelines address the topics of quality management, site, water, energy and atmosphere, materials and resources, indoor environment, and innovation. Topics not addressed by these guidelines but listed as important to consider during design include universal design, facility flexibility, regenerative design, crime prevention through environmental design, and financial impact.

U.S. Green Building Council: Leadership in Energy and Environmental Design (LEED) Green Building Rating System™ (The Rating System document is 40 pages; the Reference Guide, a user’s manual, is 280 pages)

The U.S. Green Building Council (USGBC) is a membership organization comprised of representatives from private industry, non-profit agencies, government, universities and others. The LEED rating system was developed by consensus among experts in the field. LEED is used as an integrated design guideline, as a tool to measure progress, and ultimately as a means to third party certification. There are 4 levels of certification (certified, silver, gold and platinum) based on the number of points earned. The LEED rating system does not address the procedural aspects of creating a green building, but an integrated design process is necessary for creating a certified facility. The rating system is

organized into five topic areas (sustainable sites, energy and atmosphere, water efficiency, materials and resources, and indoor environmental quality). Within each category there are specific strategies and performance requirements for earning points. This rating system has become increasingly popular in the U.S. Version 2.0 is applicable to new construction and major renovations. *LEED for Existing Buildings* is in the pilot phase (as of January 29, 2002) and other products are under development.

Commonwealth of Pennsylvania: *Guidelines for Creating High Performance Green Buildings* (approximately 50 pages)

The Commonwealth of Pennsylvania, with the support of the Governor's Green Government Council, is steering a course towards sustainable design and development. This document presents information on green design systems (team building, site, enclosure, mechanical, interiors and materials) and processes (green design and construction process, design optimization, construction documents and specifications, bidding and construction, building commissioning, and operation/maintenance), with case studies and reference sections. Each system and process section contains a checklist of considerations for "greening" facilities.

City of New York, Department of Design and Construction: *High Performance Building Guidelines* (approximately 120 pages)

This document is the result of input by numerous personnel, a consulting firm, and interagency partners. Experiences with implementing high performance demonstration projects and the work of the Environmentally Responsible Building Guidelines Project (ERBGP) have contributed to its development. The ERBGP involved research on other green building guidelines, workshops with construction industry representatives, and a financial analysis. Parts II and III of the document present the process and technical information and follow a similar format throughout for guiding the project team. These include high performance objectives, benefits, and technical strategies for meeting the objectives. Performance goals are designated as either Level 1 or 2, indicating a level of difficulty to implement.

University of Minnesota: *Minnesota Sustainable Design Guide* (approximately 120 pages)

The design guide was developed by a partnership made up of the University of Minnesota, Hennepin County, the Minnesota Office of Environmental Assistance, and Hellmuth, Obata & Kassabaum Architects, with funding from the Minnesota Office of Environmental Assistance, the Design Institute at the University of Minnesota, and Hennepin County (MN). It includes approximately 50 strategies for creating sustainable buildings and categorizes these strategies into six categories - site, water, energy, indoor environment, materials, and waste. Building on other rating systems, the document also contains a scoring system and performance indicators that must be achieved to earn points. Each strategy includes specific actions to be taken during each stage of the building life cycle (e.g, programming, design).

For convenience, the acronyms listed below will be used in the following tables to represent the guidance documents evaluated.

Table 2. Acronyms for Guidance Documents

Guidance Document	Acronym
The Poudre School District	PSD
Collaborative for High Performance Schools	CHPS
Innovative Design	ID
City of Seattle and Seattle Public Schools	SPS
Triangle J Council of Governments	TJCoG
U.S. Green Building Council	LEED
Commonwealth of Pennsylvania	PA
City of New York	NYC
University of Minnesota	MN

5.2 Goals of the Guidance Documents

The guidance documents reviewed have two similar broad goals: 1) to educate stakeholders of the built environment about concepts of high performance, green or sustainable facilities; and 2) to provide recommended strategies for creating high performance facilities. Four of the documents include performance criteria and a rating system for certifying buildings as high performance (Table 3).

Table 3. Guidance Documents Containing a Rating System

	PSD	TJCoG	CHPS	LEED	PA	NYC	ID	SPS	MN
Includes Rating System		X	X	X					X

The PSD and NYC guidelines, although they do not include rating systems, encourage the consideration of other green building rating tools such as LEED.

Table 4 lists specific goals identified in each of the guidance documents reviewed.

Table 4. Specific Goals of High Performance Guidance Documents

Specific Goals	Guidance Document
<p>“The guidelines are therefore meant to illustrate sustainable design strategies and concepts, providing a starting point for further research...The Sustainable Design Guidelines provide the framework for how Poudre School District will apply sustainability to the construction of all new schools, as well as the renovation of existing structures” (p. iii).</p>	<p>PSD</p>
<p>“The goal of this Best Practices Manual is to create a new generation of high performance school facilities in California” (p.ii). “Volume I 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... Volume II 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... Volume III is the CHPS Eligibility Criteria” (p. iii).</p>	<p>CHPS</p>
<p>“The objective of the Sustainable Schools Guide is to provide you with information that will allow your school system to make informed decisions regarding energy and environmental issues that are important to your school, community, and country” (p. 1).</p>	<p>ID</p>
<p>The goals are:</p> <ul style="list-style-type: none"> - “To show City support for the Building Excellence Program - To influence change in design and construction practices; to demonstrate schools can be built sustainably”. 	<p>SPS</p>
<p>“The aim of <i>High Performance Guidelines: Triangle Region Public Facilities</i> is to provide a roadmap for the design and construction of efficient, cost-effective, durable, and environmentally sound buildings and landscapes” (p. P1). “The guidelines have been crafted to encourage the design of facilities with low life-cycle costs through proper planning, design, construction, maintenance and operation, and reuse/demolition. This document is a useful tool to help professionals exercise due diligence in designing and constructing facilities that provide healthy and safe places for employees and visitors to carry out their activities, and that cost no more to operate over their useful life than is necessary” (p. I2).</p>	<p>TJCoG</p>
<p>“LEED is a voluntary, consensus-based, market-driven building rating system based on existing proven technology. It evaluates environmental performance from a whole building perspective over a building’s life cycle, providing a definitive standard for what constitutes a ‘green building’” (LEED Reference Guide, p.2).</p>	<p>LEED</p>
<p>The guide is “intended to familiarize decision-makers and others involved in the design, construction and development of communities and buildings with the concept of sustainability...it is hoped that once the reader becomes acquainted with the issues presented herein, they will be inspired to pursue sustainable design and development...” (p. iii).</p>	<p>PA</p>
<p>The guide will “help each participant better understand their role in producing improved, more efficient buildings with reduced environmental impacts... As a tool, the <i>Guidelines</i> are meant to both instruct and facilitate input from public agency executives and line staff; oversight agencies and elected officials; architects and engineers; subcontractors; journeymen and building custodians; and the visiting public” (p. 6).</p>	<p>NYC</p>
<p>The goals of the <i>Design Guide</i> are to:</p> <ul style="list-style-type: none"> - “Educate designers, building owners, operations staff, and occupants about the concepts, goals, and significance of sustainable design. - Develop an orderly decision-making process with measurable outcomes... - Provide flexibility in the way priorities are set and outcomes are measured... - Organize information in a hierarchy that permits users to easily understand the entire process but then allows them to go into more detailed information as needed to implement the system. - Create a system that can easily grow and change as more experience and new information becomes available” (Overview section). 	<p>MN</p>

Summary:

Highlighting key words in Table 4 and combining those with similar meanings led to the resulting list of 8 specific goals. The term “high performance” is used here to also mean green or sustainable.

- Illustrate high performance design strategies
- Encourage/inspire change to create high performance buildings
- Inform/educate stakeholders
- Provide a framework/roadmap for design and construction
- Help professionals exercise due diligence
- Facilitate input from stakeholders
- Help stakeholders understand their roles in the process
- Provide flexibility for setting priorities and measuring outcomes

5.3 Describing High Performance Schools

Table 5 includes several definitions of high performance, green or sustainable schools (or other facilities). Those that are unshaded (Table 5a) are from guidance documents further evaluated in this paper, while those in gray-scale (Table 5b) are from additional sources.

Table 5a. Definitions of High Performance/Sustainable/Green Schools Obtained From Documents Evaluated in This Study

Definition	Source
<p>“Sustainable Design is the systematic consideration, during design, of a project’s life cycle impact on environmental and energy resources...While responsible stewardship of the environment is important, sustainable design also provides a better physical environment for students and staff, at lower life cycle costs for the school district” (p. 1-1).</p>	<p>Poudre School District, CO</p>
<p>“High performance entails designing, constructing, and operating facilities with a focus on the following:</p> <ul style="list-style-type: none"> - Sustainability, which is a long-term view that balances economics, equity, and environmental impacts; - An integrated approach, which engages a multidisciplinary team at the outset of a project to work collaboratively throughout; and - Feedback and data collection, which quantifies both the finished facility and the process that created it and serves to generate improvements in future projects” (p. P1). 	<p>Triangle J. Council of Governments, High Performance Guidelines, NC</p>
<p>“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 (ADA), reduce liability, while at the same time being friendly to the environment” (p. ii, Volume I).</p>	<p>Collaborative for High performance Schools, CA</p>
<p>“...green buildings embody a design intent on balancing environmental responsiveness, resource efficiency, and cultural and community sensitivity. The goal of this process is to create buildings that meet the needs of current building occupants while being mindful of the needs of future generations” (LEED Reference Guide, Version 2.0, p. 1).</p>	<p>U.S. Green Building Council</p>
<p>“Simply stated, sustainable design and development is good design” (p.i). A high performance green building is one that:</p> <ul style="list-style-type: none"> - Is created using a collaborative team approach - Engages the local and regional communities in all project stages - Integrates systems to improve efficiencies and human performance - Considers true costs of its impact on the environment - Considers life cycle costs - Provides opportunities for interaction with the natural environment - Uses resources efficiently - Can be easily reconfigured and reused - Has healthy indoor environments - Uses appropriate technologies before more complex solutions - Includes environmentally sound operations/ maintenance - Educates occupants and users <p>(p. iii).</p>	<p>Commonwealth of Pennsylvania Kobet et al.</p>
<p>“From the project outset, these building owners, designers, and contractors [of high performance buildings] [are] actively committed to maximizing operational energy savings, providing healthy interiors, and limiting the detrimental environmental impacts of the buildings’ construction and operation” (p.14).</p>	<p>City of New York</p>
<p>“The concept of sustainable development reflects an understanding that we must meet the needs of the present without compromising the ability of future generations to meet their own needs. A Sustainable School not only embraces the concept of sustainability but is, in itself, a teaching tool for sustainability” (p.1).</p>	<p>Innovative Design</p>
<p>“For a school to be built ‘sustainably’ implies the building’s designers and builders have achieved an ideal – a building that uses resources at the same rate (or less) than the rate at which they can be replenished” (p. i).</p>	<p>City of Seattle</p>
<p>Not defined, per se, in the guidance document itself.</p>	<p>University of MN</p>

Table 5b. Definitions of High Performance/Sustainable/Green Schools Obtained From Other Sources

Definition	Source
<p>“A sustainable school is one that maximizes the educational opportunities in its total life to create a learning community committed to a more sustainable future”.</p>	<p>New Jersey Sustainable Schools Network http://community.nj.com/cc/sustainableschools</p>
<p>The high performance task force promotes “design and construction standards for school renovation and construction which minimize energy consumption, produce an optimum learning environment, avoid the use of toxic materials or materials which produce indoor air quality problems and are appropriate to the local climate and environment”.</p>	<p>Charleston County Parents for Public Schools, High Performance Task Force in South Carolina www.southconnect.com/ccpps/high_performance_schools.htm</p>
<p>“Sustainable ‘green’ schools are places where it is obvious that there is a concern for a sustainable future. ‘Green’ schools bring together environmental education and education reform by using curriculum and instructional strategies that are interdisciplinary and experiential, require parental and community involvement, have real-life applications and create ecological literacy. ‘Green’ schools encompass more than the building envelope; they also include the students and the curriculum”.</p>	<p>(Kirkbride 2000) “Green (Sustainable) Urban Educational Facilities”</p>
<p>“Green schools...are designed based on principles of resource efficiency and environmental sustainability”.</p>	<p>Tremain 1999 “Little Green Schoolhouse”</p>
<p>“A resource efficient school uses fewer resources and provides a higher quality learning environment than a school built with conventional design and construction practices”.</p>	<p>Washington State University Cooperative Extension Energy Program www.es.wapa.gov/pubs/briefs/schools/tb_schools.cfm</p>
<p>“Environmentally sustainable design of buildings refers to maximizing a building’s positive impacts on nature, and minimizing its negative impacts, over the whole of its life”.</p>	<p>(Gelder 1998) “Teaching Environmentally Sustainable Design in Schools”</p>
<p>“Sustainability is a principle which states that economic growth (i.e., the generation of wealth) can and should be managed so that natural resources are used in such a way that the resource needs of future generations are assured”.</p>	<p>(Weiss 2000) “Sustainable Schools”</p>

In addition to the definitions provided above, guidance documents (un-shaded) and other sources (gray-scale) describe the attributes of high performance facilities (Table 6). Those sources that are not guidance documents were included to determine whether or not there is consistency in the field regarding attributes of high performance facilities.

Table 6. Attributes of High Performance/Sustainable/Green Schools

Attributes	Source
<p><i>Features of sustainable schools:</i></p> <ul style="list-style-type: none"> - Sustainable site planning and landscape design - Renewable energy sources - High quality and energy efficient lighting - Energy efficient shell - Energy efficient HVAC - Eco-education - Environmentally preferable building materials - Water conservation - Recycling and waste management - Construction waste reduction and recycling - Commissioning 	<p>Poudre School District</p>
<p><i>A high performance school is:</i></p> <ul style="list-style-type: none"> - Healthy - Thermally, visually and acoustically comfortable - Energy efficient - Material efficient - Water efficient - Easy to maintain and operate - Commissioned - A building that teaches - Safe and secure - A community resource - Stimulating architecture - Adaptable to changing needs - Has an environmentally responsive site 	<p>Collaborative for High Performance Schools</p>
<p><i>Thirteen Components of Sustainable School Design:</i></p> <ul style="list-style-type: none"> - Site planning and landscape design - Daylighting - Energy efficient building shell - Solar systems - Efficient lighting and electrical systems - Efficient mechanical and ventilation systems - Environmentally sensitive building products/systems - Indoor air quality - Water conservation - Recycling systems and waste management - Transportation - Commissioning and maintenance - Eco-education 	<p>Innovative Design</p> <p>Also: SHW Concepts 1998 www.shwgroup.com/Textpg3.pdf</p>
<p><i>Principles of resource efficiency:</i></p> <ul style="list-style-type: none"> - “Energy efficiency: Promotes efficient use of energy resources while minimizing environmental impacts and meeting economic goals. - Resource conservation: promotes efficient use of resources through water conservation, solid waste management, and the selection of resource-efficient building materials - Environmental quality: promotes healthy and non-toxic indoor and outdoor environments” 	<p>City of Seattle and Seattle Public Schools</p>

Attributes	Source
<p><i>Principles of high performance buildings:</i></p> <ul style="list-style-type: none"> - Sustainability: use renewable resources, create resource use cycles (mimic nature), approach the design and construction using systems thinking - Integrated facility design and construction: consider the interactions of all building systems and components when designing individual building systems and components - Feedback and data collection: quantify and disseminate the performance of systems, process efficiencies and costs 	Triangle J. Council of Governments
See Table 1a	U.S. Green Building Council,
<p><i>A high performance green building:</i></p> <ul style="list-style-type: none"> - Collaborative team approach - Engages local and regional communities - Considers integrated systems - Considers “true cost” on the environment - Considers life cycle costs - Opportunities to interact with the natural environment - Uses resources efficiently and maximizes local materials - Minimizes construction and demolition wastes - Energy and resource efficient - Reconfigured and reused - Healthy indoor environments - Appropriate technologies - Environmentally sound O/M - Educates building occupants and users 	Commonwealth of Pennsylvania
<p><i>High performance buildings:</i></p> <ul style="list-style-type: none"> - are energy and resource efficient - reduce waste - provide other measurable benefits such as improved worker productivity and cost savings 	New York City
Not specifically stated in the design guide	Minnesota
<p><i>Sustainable schools include:</i></p> <ul style="list-style-type: none"> - Waste reduction - Renewable resource use - Replacement resource generation - Fossil fuel reduction - Healthy and safe schools with reasonable operating costs - School as educational tool and community resource 	Weiss 2000 “Sustainable Schools” www.neetf.org/pubs/NEETF8400.pdf
<p><i>High performance, sustainable schools:</i></p> <ul style="list-style-type: none"> - Are sited for climatic conditions - Enhance indoor environmental quality - Conserve energy and make use of renewable resources - Protect and conserve water - Minimize construction waste - Optimize maintenance and operations 	Sustainable Buildings Industry Council www.SBICouncil.org

Attributes	Source
<p><i>Green schools consider:</i> (Modified from Tremain, 1999)</p> <ul style="list-style-type: none"> - Site Preservation: Maximize natural conditions, design access for pedestrians, bikes and public transit, site protection during construction. - Building Enclosure: Energy-efficient shell, use windows to maximize solar gain in winter and minimize summer heating - Resource Conservation: Consider passive energy systems, conserve water, use environmentally sensitive building products and systems, encourage recycling, address transportation (e.g., car-pooling, alternative fuel vehicles). - Interior Quality: Enhance indoor air quality, optimize daylighting, optimize acoustics. - Operations and Maintenance: Design for on-going building commissioning - Education: Design school as a teaching tool - Community: Work with community to establish importance of place, design school to function as a center of community 	<p>Pollution Prevention Resources Center www.pprc.org/pprc/pubs/topics/schools/apply.html</p>
<p><i>Green schools are designed to take advantage of:</i></p> <ul style="list-style-type: none"> - Natural drainage - Sun orientation - Vegetation - Locally produced building materials - Recycled building materials - Natural lighting - Advanced computer systems to model and monitor resource usage <p>“Students become active learners by studying, maintaining, and even designing their schools’ environmental features”.</p>	<p>Tremain 1999 “Little Green Schoolhouse”</p>
<p><i>Principles of sustainable design:</i></p> <ul style="list-style-type: none"> - Save energy and water - Reduce maintenance costs - Encourage recycling - Enhance occupant health 	<p>Kennedy 2001a “Top Ten: Facility Design and Planning Solutions”</p>
<p><i>Green building design includes:</i></p> <ul style="list-style-type: none"> - Access for pedestrians, bicycles, mass transit - Minimizing east-west exposure - Windows to maximize winter solar gain and minimize summer heat gain. - Solar energy use - Use school design in curriculum - Ensuring good indoor air quality - Storm water management - Gray water recycling - Building commissioning 	<p>Dentch 2000 “Building a Better Learning Environment”</p>

Summary:

Tables 2 and 3 illustrates that the terms “high performance”, “green” and “sustainable” are described according to 1) processes that are important when creating a high

performance facility, 2) design considerations, and 3) outcomes resulting from high performance design and construction. These have been categorized below.

Process Considerations

- Integrated design/collaborative team approach
- Building commissioning
- Community involvement
- Feedback and data collection
- Recycling and waste reduction

Design Considerations

- Sustainable sites and landscapes
- Minimization of east-west exposure
- Renewable energy sources
- Efficient systems
 - Lighting
 - Mechanical
 - Shell
 - Water (including gray water)
- Day lighting
- Materials
 - Environmentally sensitive
 - Local
- Transportation options (e.g., pedestrian and bike ways, near public transit)
- Mimic nature
- Opportunities to interact with nature
- Appropriate technologies
- Computer systems for monitoring
- Storm water management

Outcomes

- Societal impacts
 - Resource conservation
 - Environmental protection
 - Building as a community resource
- Building operation and maintenance
 - Ease of operation/maintenance
 - Reduced liability
 - Lower life cycle costs
 - Adaptable facility
- Health and comfort
 - Indoor air quality
 - Thermal comfort
 - Visual comfort
 - Acoustical comfort
- Teaching and learning

- Teacher retention
- Higher test scores
- Improved attendance
- Ecological literacy/building as a teaching tool
- Safety and security

To evaluate the guidance documents in terms of the attributes of high performance schools they address, those attributes that were listed three or more times in Table 6 have been categorized into broader groups to include commissioning, providing a community resource, waste reduction, sustainable sites, transportation, renewable energy, resource conservation (e.g., energy, water), reduced operation and maintenance costs, healthy indoor environments, and teaching and learning. Table 7 indicates which of these attributes are addressed by each guidance document.

Table 7. Attributes of High Performance Schools Addressed

<i>Attributes</i>	PSD	CHPS	ID	SPS	TJCoG	LEED	PA	NYC	MN
Process Considerations									
Commissioning	X	X		X	X	X	X		
Community Resource			X						
Waste Reduction	X		X	X	X	X	X	X	X
Design Considerations									
Sustainable Sites	X	X	X		X	X	X	X	X
Transportation		X	X		X	X		X	X
Renewable Energy	X	X	X		X	X	X	X	X
Outcomes									
Resource Conservation	X	X	X	X	X	X	X	X	X
Reduced O/M Costs		X	X		X	X	X	X	X
Healthy Indoor Environments	X	X	X	X	X	X	X	X	X
Teaching and Learning	X		X						

An “X” indicates that the document meets the following criteria:

Commissioning: Includes recommendations for initial and/or continuous building commissioning.

Community resource: Includes strategies or a discussion on the importance of using the building for purposes considered important to the community after it is completed. For example, a school facility that allows the Cub Scouts or recreation sports leagues to use the facility would be one that provides a community resource. An “X” is not assigned here if the document discusses the importance of involving the community during the design process.

Waste reduction: Includes strategies for reducing waste during construction (e.g., land clearing debris, unused materials), operation (e.g., solid waste) or at the end of the building's useful life (e.g., demolished or salvaged material).

Sustainable sites: Includes strategies or discussion aimed at optimizing natural site features, protecting the site during construction, orienting the building to optimize solar exposure, etc. An X is not included for landscaping strategies aimed at water use reduction.

Transportation: Includes strategies to encourage walking, bicycling, carpooling, using mass transit or alternatively fueled vehicles.

Use renewable energy: Includes strategies that encourage the use of technologies that are powered by solar or other renewable energy sources.

Resource conservation: Includes strategies aimed at reducing the use of natural resources such as energy and/or water.

Reduced operations/maintenance costs: Includes strategies that will likely reduce operation and maintenance costs. Such strategies include efficient mechanical systems, water conserving fixtures, and daylighting.

Healthy indoor environments: Includes strategies aimed at providing an indoor environment that is not harmful to occupants. Such strategies include increased outdoor air ventilation, the use of products with low volatile organic compound content and replacing filters regularly.

Teaching and learning: Includes strategies or a discussion on how to utilize the building to teach concepts related to high performance design and construction. An "X" is not assigned if the document merely mentions the importance of educating colleagues.

Summary:

Only the guidance documents developed specifically for schools address the two attributes of using the building as a teaching tool and as a community resource. Although most of the descriptions of high performance schools include these attributes, not all of the four school guidance documents address either of these. These issues must be addressed in design guides if these goals are to be achieved. If they are considered an afterthought, the success of using the school as a teaching aid or as a community resource will be diminished. For example, if a school is to be used by community groups such as the Cub Scouts or county recreation programs, the lighting and mechanical systems must be designed so that the appropriate spaces can be conditioned and lit without wasting energy on unoccupied spaces. Also, cut-aways can be incorporated into the design so that high performance building features are visible to educate students, staff and visitors. The goal of using the facility as a teaching tool could also be successfully achieved by other types of facilities. Perhaps making high performance building features visible to

occupants and guests in other facilities would encourage more owners (including home owners) to demand high performance design, construction, operation and maintenance practices.

5.4 Organizational Structure of Guidance Documents

Among the guidance documents reviewed, there are various approaches to organizing and presenting information. Four broad organizational categories were identified in this evaluation. These categories include:

- Building life cycle phases/processes (e.g., design, construction, commissioning)
- Building systems (e.g., HVAC, windows)
- Topics (e.g., water, site, financing)
- Physical environmental conditions (e.g., acoustics, thermal comfort)

The major headings and subheadings were reviewed to identify whether or not they address these categories (and their sub-categories) listed above. Table 8 presents this information. An X is assigned if these categories are included in either the first or second level of the table of contents (headings or subheadings). All of the specific design strategies were not included in this table, even if these were included in the sub-headings. Only those considered part of the organizational structure of the documents for the purposes of this paper were included in Table 8.

While most of the documents include background information, benefits of high performance schools, and references, this table is devoted to evaluating how the procedural and technical information of the design guides are organized. The absence of an X for each category does NOT mean that the item is not addressed within the document; it simply indicates that it is not included in the headings or subheadings.

Table 8. Approaches to Organizing the Guidance Documents

	PSD	CHPS	ID	SPS	TJCoG	LEED	PA	NYC	MN
Building Life Cycle Phases/Other Processes									
Planning/Pre-design	X	X					X	X	X
Design ^a	X	X	X	X	X	X	X	X	X
Construction	X	X		X	X	X	X	X	X
Operation/Maintenance		X		X			X	X	X
Deconstruction Demolition or Disposal									X
Commissioning	X	X			X	X		X	
Other Processes	X	X	X		X		X	X	X
Building Systems									
Enclosure	X	X	X	X			X	X	X
Mechanical	X	X	X	X	X	X	X	X	X
Lighting	X	X	X	X	X	X		X	X
Windows		X	X						
Other Equipment or Systems		X			X	X		X	X
Topics^b									
Site	X	X	X	X	X	X	X	X	X
Energy				X	X	X		X	X
Energy analysis tools		X							
Renewable energy	X	X	X		X	X			X
Materials	X	X	X	X	X	X	X	X	X
Water	X	X	X	X	X	X		X	X
Indoor environment/interiors	X	X		X	X	X	X	X	X
Waste (construction and/or collection and recycling)	X		X	X	X	X		X	X
Safety/security, health and/or comfort		X	X					X	X
Transportation			X		X	X		X	X
Financing Issues		X	X					X	
Physical Environmental Conditions									
Acoustics		X			X			X	X
Thermal comfort		X			X	X			X
Visual comfort		X						X	X
Indoor air quality	X	X	X		X	X		X	X
Individual controls					X	X		X	
Views/contact with nature					X	X			X

a Although design is not specifically stated in the headings or sub-headings in all of the documents, an X is included for all since the documents primarily address design.

b There are topics included in headings and subheadings in the guidance documents that do not appear in the table (general conditions-CHPS; reducing operating costs – CHPS,ID; improving academic performance, environmental protection, community support, eco-education – ID; and relocatable classrooms – CHPS). For simplicity, only those topics used as headings or subheadings in 3 or more of the documents appear in Table 8.

Additional information about the organizational structure of the documents is presented below.

PSD: The major headings include: introduction; the sustainable design process; the sustainable design product; and, tools and resources for designing sustainable schools. Other processes not specified in the table include project management, procurement, charrettes and commissioning. Commissioning, however, is not included under the “sustainable design process” heading, but rather under “sustainable design product”.

CHPS: Major headings in Volume I are: understanding high performance schools, health and productivity issues, financing high performance schools, process guide, discussion guide and case studies. Volume II major headings are: introduction, general conditions, site planning, interior surfaces and furnishings, electric lighting and controls, daylighting and fenestration design, building enclosure and insulation, and HVAC. Processes addressed that are not specified in the table above include “Key Steps in the Process”, “Building a School in California”, and “Steps in the Process”. The discussion guide is organized by building life cycle phase. For each phase included there are specific recommendations for achieving the following:

Superior indoor air quality	Commissioning
Acoustic comfort	Renewable energy
Thermal comfort	Environmentally preferable materials and products
Visual comfort	Environmentally responsive site planning
Daylighting	High performance HVAC
Safety and security	High performance electric lighting
Life cycle cost analysis	Water efficiency
Energy analysis tools	

Three case studies are also included in Volume I. *Volume II- Design* is the technical information organized according to discipline and is primarily intended for the architects and engineers. Volume III contains the performance objectives and rating tool.

ID: This document is the only one organized around broad goals of sustainable schools. These include:

- Reducing operating costs
- Buildings that teach sustainability
- Improving academic performance
- Protecting our environment
- Designing for health, safety and comfort, and
- Supporting community values

Within each of these sections are sub-headings (e.g., lighting and electrical systems, site design) and specific recommendations. The advantage of such an organizational approach is that one can target decision-makers based on their goals. Suppose a decision-maker is not “sold” on the concept of sustainable schools, but is very interested in reducing operating costs and improving academic performance. By giving that decision-maker

only the sections pertaining to these goals, perhaps he or she would be interested in incorporating sustainable strategies aimed at achieving them. After experiencing small successes with sustainable design, larger successes may follow.

SPS: This is the only document written as three stand-alone documents. Major headings for Section I and Section II (design phase and build-out phase) include: introduction, energy efficiency, resource conservation – water conservation, resource conservation – solid waste management, resource conservation – building material selection, and environmental quality. Section III contains nearly identical headings.

TJCoG: A major heading that is unique to this document is “quality management” that includes “basic quality management” and “comprehensive building commissioning”. For buildings to earn points for certification using the rating system, there are six prerequisites that must be met under “Basic Quality Management” and include: develop a plan of work, identify key processes and key process indicators, develop a matrix of performance expectations for each project team member that identifies responsibilities, adopt process flow charts to establish standards for how processes are carried out, identify the metrics and reporting format that will be used to track success, and identify “key process champions” responsible for monitoring and improvement to key processes. The other major headings include site, water, energy and atmosphere, materials and resources, indoor environment, and innovation. Case studies and an appendix follow.

LEED: The 40-page basic document is only a summary. The Reference Guide contains background information, case studies, benefits or other similar information like the other documents reviewed. Version 2. LEED is organized by five major headings: sustainable sites, water efficiency, energy and atmosphere, materials and resources and indoor environmental quality.

PA: Major headings include: introduction, green design systems, green design process, case studies, and references/resources. Processes not specified in the table above include green team building and goal setting. Each section under the headings “Green Design Systems” and “Green Design Processes” includes checklists with specific strategies for achieving green objectives.

NYC: The NYC guidelines are organized around the “high performance objectives that cut across multiple disciplines and technical areas of expertise” instead of by technical area. Part 1 of the document contains a 24-page overview of the guidelines, how to use them, characteristics of high performance buildings, benefits, etc. Part 2 contains information on the processes and Part 3 contains the technical information and high performance strategies. Part 4, the end pages, contains the acknowledgements, a glossary, index and appendices.

MN: One section of this document is devoted to building life cycle phases and identifies specific steps to be taken, deliverables, and resources for each phase. The remainder of the document is devoted to the six environmental topics: site, water, energy, interior environment, materials and waste. Within each of these categories are the purpose,

performance indicators, and resources for each strategy. There are various numbers of points that can be earned for each strategy. Additionally, each one includes specific actions for each applicable phase in the building life cycle. This is the only document reviewed that includes these specific measures to be taken throughout the building life cycle for each sustainable strategy.

Summary:

Several documents, including PSD, PA and NYC separate processes (e.g., charrettes) from technical information (e.g., water management, renewable energy). It is interesting to note that two of these (PSD, PA) include some design-related processes (e.g., site design) with the more technical information, while other non-design types of processes are addressed under a separate category. For example, PSD categorizes project management and procurement under “The Sustainable Design Process”, while site planning, landscape design and commissioning are categorized under the heading “The Sustainable Design Product: Eleven Features of Sustainable Schools” heading, even though these too are processes. In the PA document, green team building and goal setting are included under the heading “Green Design Systems” rather than “Green Design Process”.

The CHPS, LEED, TJCoG and NYC documents all contain five of the same topic areas listed as major headings, although they may be given slightly different names. These include, site, energy, water, materials, and indoor environment.

5.5 Intended Readers of the Guidance Documents

This section is devoted to the identification of intended readers of the guidance documents (Table 9), rather than those stakeholders who are ultimately affected by the facilities that are built using these guidelines. This information was obtained by reviewing the introductory sections of each document to identify intended users. The absence of an “X” does not mean that the stakeholder is not important in the facility design and delivery process, but rather that the stakeholder is not necessarily an intended reader of the document. A capital “X” indicates that the document explicitly identifies the intended readers, whereas a lower-case “x” indicates that the document implicitly identifies use by these stakeholders. For example, if a document states that the guideline is intended to “familiarize those involve in the construction ...” a capital “X” is used by “construction team”. If a document mentions that an integrated project team may include facility managers, a small “x” is used for that category.

Table 9. Intended Readers of Guidance Documents

<i>Direct Stakeholders as Intended Readers^a</i>	PSD	CHPS	ID	SPS	TJCoG ^d	LEED	PA	NYC	MN ^d
Owner	X	X	X ^e		x	X	x	X	X
Land Developers					x	x	x	x	x
Users/Tenants		X				X	x	X	X
Facility Managers		X		X			x		
Operators	x	X		X		X			X
Clients									
Planners		X					x		
Developers							X		
Design Team ^b	X	X	X	X	X	X	X	X	X
Construction Team		x		X	X	X	X	X	x
Utilities	x								
Financiers							x	X	
Surrounding Communities		X				X	X	X	
Project Managers	X	X			x	x	x	x	x
Demolition Contractor									
Disposal Agent						X		X	
Salvage Agents									
Indirect stakeholders ^c	X	X		X		X	X	X	

- a Direct Stakeholders (internal and external) as identified in (Pearce 1999), synthesized from five other sources.
- b Each guidance document does not specifically state that designers are intended readers, however, these are all noted as a capital “X” since each primarily addresses design.
- c There are numerous potential indirect stakeholders. All stakeholders not specifically identified above are listed in Table 10 below.
- d Intended readers other than the stakeholders identified here are addressed by the guidance document because specific action items are designated for each phase of the building life cycle. However, no attempt was made here to speculate which intended readers correspond to each life cycle phase.
- e The document addresses “you”, assumed to be the school district, considered owners in this table.

Below (Table 10) is a listing of other intended readers that are specified in the guidance documents but were not specified in the table above.

Table 10. Additional Intended Readers

PSD	Procurement (contracting) personnel, commissioning agents, educators, contracted design and professional service firms, Fort Collins Utilities, Colorado State University design and engineering faculty, and U.S. Department of Energy buildings specialists.
CHPS	“Superintendents, parents, teachers, school board members, administrators, and those persons in the school district that are responsible for facilities”.
SPS	Contractors
TJCoG	Owners include local governments and schools in the Triangle J. Region.
PA	Decision-makers (in general). Other stakeholders that may be included in the project team that are not included in the table above are consultants (design team), contractor and subcontractors (construction), suppliers and government agencies (indirect stakeholders), and those involved with development of communities (planners, land developers)
NYC	Public agency executives and line staff, elected officials, journeymen, subcontractors (construction), regulatory and other agencies, trade associations, commissioning agents, cost estimators, public clientele, city taxpayers, other municipalities and interested real estate professionals are stakeholders not specifically included in Table 9. Owners include sponsoring agencies, the Department of Design & Construction Program Managers and Architecture & Engineering. The design team includes architects, landscape architects, horticulturalists, civil engineers, mechanical, electrical, and structural engineers. The construction team includes construction managers, cost estimators, commissioning agents, contractors, subcontractors.
LEED	Materials manufacturers, contractors

Summary:

Each guidance document is intended for multiple types of intended readers. However, they are not organized according to the specific stakeholders addressed. Therefore, each stakeholder may need to read the entire document to identify relevant sections. The NYC document, however, is one exception. It does clearly specify which sections of the document pertain to specific stakeholders by using a matrix and icons near the front of the document. The documents that include building life cycle phases in the headings or subheadings, such as PA and MN, may facilitate their use by specific readers involved in various building phases. The MN design guide specifies action items for each building life cycle phase with each recommended strategy so that stakeholders involved with those phases can address these issues.

While the PA guidelines state that the document is “intended to familiarize decision-makers and others involved in the design, construction and development of communities and buildings” with sustainability, the strategies and checklists are aimed mostly at owners and the design team, with a few exceptions. For example, the operations/maintenance checklist contains information for facility maintenance personnel such as “adhere to all recommendations set forth in warranty and maintenance recommendations for building components and equipment”. Other strategies are appropriate for designers, such as “include O & M concerns and design criteria in the early planning stages” and still others are intended for unclear stakeholders (e.g.,

“educate all building occupants and other appropriate parties about the goals and benefits of the O & M program. Strive for maximum compliance”). The section on commissioning seems intended for owners and designers, but does not necessarily include information that a commissioning agent would find useful.

In fact, most of the documents reviewed primarily address the design team, while providing a minimal number of recommendations for the construction team and facilities personnel. There is typically very little information intended for other members of an extended project team, such as occupants or representatives from the local community. The majority of the documents call for a shift from the traditional, linear approach to facility design and delivery to an integrated team approach where key stakeholders work together from the beginning of the process to ensure that sustainability goals are met. The team consists of many stakeholders, possibly including the owner, future users/occupants, building manager, architects, engineers, consultants, construction managers, contractors, subcontractors, suppliers, government agencies, members of the local community and others. It may be appropriate to concisely provide other types of information to stakeholders, such as community representatives or future occupants, to help them understand and contribute to the high performance design process. Another approach would be to reorganize guidance documents based on stakeholder-specific information, ensuring that the language and level of detail are appropriate for the reader.

5.7 Building Life Cycle Phases Addressed

For this section, each document was reviewed to identify which phases of the building life cycle are addressed. The following simple descriptions of the building life cycle phases were used to identify those addressed by each guidance document.

Pre-design/Planning: This phase of the building life cycle includes every step that occurs prior to when the architect begins putting ideas on paper, so to speak. During this phase, someone initiates a new construction or renovation project and strategic planning occurs. For this paper, the selection of a project team is included in the planning stage. Programming is an important process in which all of the user requirements are clearly defined (e.g., the number of classrooms, a library, cafeteria). A site is selected for the project if it is a new construction and site planning occurs for new or existing buildings during this phase.

Design: This is the phase during which the requirements are translated into a schematic design prior to design development. Design optimization, the process whereby cost analyses, energy and/or lighting simulations may be run, occurs to ensure that the design meets high performance and other programming requirements. Time and cost are also important considerations during design optimization. The construction documents and specifications are written for the construction team to implement.

Construction: Before construction can begin, the prime contractor must be selected through a process of bids, negotiations and awarding of the contract. Construction planning precedes actual construction. Building commissioning typically occurs after the

facility has been completed to ensure that all systems are operating and performing as intended. Commissioning throughout the entire building life cycle is recommended for ensuring that a high performance facility continues to perform as intended.

Operation/Maintenance: This is typically the longest phase of the building life cycle. Start up occurs when all systems are operating and occupants move in to use the facility. Operations/maintenance management is the process of running building systems, cleaning, repairing equipment and other products, and maintaining the facility (e.g., painting, roof replacement). Also included here is the decision to reuse, deconstruct and salvage, move, or demolish the facility at the end of its useful life.

An X indicates that there are recommendations included in the document that clearly address the indicated life cycle phase. There are four different scenarios for which an X is used. First, an X is used to indicate that recommended strategies include a word or words that are derivations of the building life cycle phase (e.g., design, specify, during construction, maintain). For example, an X is placed in the “construction documents & specs” box if there are recommendations that state, “specify” certain types of technologies or practices. An X is placed in the O/M management box if a recommended strategy is “Create a maintenance plan...”. Second, if a heading or subheading (e.g., construction administration) addresses the building life cycle phase, an X is placed in the appropriate box. Third, an X is used if there is a discussion about considerations that must be taken into account during a particular life cycle phase. For example, if there is a discussion about the importance of bringing together all project stakeholders early in the planning phase, an X is placed in the “strategic planning” box. Finally, if a guidance document specifically includes action items to be taken during particular phases of the building life cycle, Xs will be placed in those boxes. The absence of an X does not mean that there are no recommended strategies that must be considered during a particular life cycle phase. No attempt was made to infer when during the building life cycle the recommended strategies would be considered. The results are included in Table 11.

Table 11. Building Life Cycle Phases Addressed

<i>Life Cycle^a</i>	PSD	ID	CHPS	SPS	TJCoG	LEED	PA	NYC	MN
Planning/Pre-design									
Project initiation					X			X	X
Strategic planning			X		X		X	X	
Programming			X	X	X			X	X
Site selection/ planning	X	X	X		X	X	X	X	X
Design									
Design optimization	X			X	X	X	X	X	
Conceptual/schematic design			X	X	X			X	X
Design development	X	X	X	X	X	X	X	X	X
Construction documents & specs			X	X	X	X	X	X	X
Construction									
Bid/negotiate/award	X		X		X		X		X
Construction	X	X	X		X	X	X	X	X
Commissioning	X		X	X	X	X	X	X	X
Operation/Maintenance									
Start-up			X		X	X		X	X
O/M management		X	X		X	X	X	X	X
End or Service Life Decision					X				X

a Based on University of Minnesota 2000; Triangle J Council of Governments 2001

The building life cycle phases are not, in reality, as clear-cut as indicated above. Often, the phases overlap with one another, but for simplicity they are shown as discrete phases for the purposes of this paper. For high performance buildings to be delivered, however, it is important that the stakeholders that were traditionally not brought on board until the latter phases of building life cycle be a part of the team much earlier in the process. This type of integrated design approach helps to ensure that high performance goals are met (Barnett and Browning 1995; Vanegas et al. 1998).

Summary:

Each guidance document addresses each of the four major building life cycle phases (planning and pre-design, design, construction and operation/maintenance) to some degree, with the exception of PSD that does not address operation/maintenance. What is not evident from the table that becomes clear when reviewing the documents is that the vast majority of recommendations and strategies are best addressed in the design phase. There are fewer recommendations for the construction and operation/maintenance phases. Some examples include “Develop and follow a construction waste management plan...” (TJCoG). Several documents include construction-related strategies that address waste management issues, but ignore a wide variety of others that might be included, such as duct sealing (e.g., use mastic to seal ductwork). Of the documents reviewed, the MN and SPS provide the most information for the operation/maintenance phase. The MN document includes action items for appropriate life cycle phases with each recommended

strategy. For each chapter, the NYC document includes a list of deliverables to be obtained during applicable life cycle phases.

5.8 Physical Environmental Conditions That Affect Learning

The physical variables included in Table 12 have been derived from the literature review summarized in Appendix A and represent several factors that have been shown to affect student learning or behavior to some degree. Each of the guidance documents was evaluated in terms of whether or not they directly addressed these physical variables.

Table 12. Physical Environmental Conditions Addressed by the Guidance Documents

<i>Physical Variables</i>	PSD	CHPS	ID	SPS	TJCoG	LEED	PA	NYC	MN
Building age ^a									
Building condition ^a									
Privacy amenities									
Interior spaciousness									
Electric lighting ^b	X	X	X	X	X	X	X	X	X
Daylighting ^b	X	X	X	X	X	X	X	X	X
Interior finishes	X	X	X	X	X	X	X	X	X
Acoustics		X	X		X		X	X	X
Furniture type & arrangement									
Classroom adaptability									
Open vs. closed classrooms									
Temperature ^c	X	X	X		X	X	X		X
Relative humidity ^c	X	X	X		X	X	X		X
Indoor air quality/ presence of pollutants	X	X	X	X	X	X	X		X
Safety & security		X							

- a These two are not specifically addressed by the guidance documents. The guidance document can apply to facilities of any age. The documents do address overall building condition when used in their entirety, although many elements of building condition (e.g., tears in carpet, damaged furniture) are not addressed.
- b The guidance documents may address daylighting from the perspective of energy efficiency and/or with respect to visual comfort/quality.
- c The guidance documents address “thermal comfort”. Temperature and humidity are two of the important factors that contribute to thermal comfort. Humidity is also an important factor regarding indoor air quality and is addressed by several guidance documents from this perspective.

Summary:

There is considerable consistency among the guidance documents in addressing certain physical environmental conditions (lighting and daylighting, interior finishes, acoustics, temperature and humidity, and indoor air quality). Other variables, such as privacy amenities, interior spaciousness, furniture type and arrangement, classroom adaptability, open versus closed classrooms, and safety and security receive little or no attention. It is

important for design teams to acknowledge that addressing high performance requirements does not guarantee that the facility will be optimal for learning. High performance design guides must be used in the context of all requirements and conditions that contribute to learning. Perhaps there is yet another group of stakeholders, researchers who study the impacts of physical environmental features on learning, who can play a larger role in developing resources for school facility decision-makers. This is occurring to some extent already.

6.0 Conclusions

In order to handle increasing enrollments and deteriorating school facilities, an increasing number of school systems across the U.S. are seeking to create high performance schools as a way to provide optimal learning environments, reduce operating costs, and protect the natural environment. Guidance documents, such as those reviewed in this paper, are important tools for disseminating information and facilitating discussion to promote high performance design, construction, and operation/maintenance of school facilities. These documents are intended to illustrate high performance design strategies, educate stakeholders, provide a framework for the design and construction process, facilitate input from stakeholders, and help them understand their roles in the process. The approach to organizing information is quite different for each document. However, all four of the documents that include a rating system (LEED, CHPS, TJCōG, MN) have five categories in common, including site, energy, water, materials, and indoor environment.

The nine guidance documents reviewed in this study appear to make valuable contributions toward promoting high performance facility design. They include numerous recommendations for improving the facility delivery process and specific strategies for improving the sustainability of buildings. The stakeholders intended to read the documents range from owners, designers, contractors, and maintenance staff to government representatives, occupants, and members of the local community. However, the documents do not address all of their intended stakeholders equally. Designers (architects and engineers) and owners are most likely to benefit from using the design guides. Overall, there are fewer recommended strategies for implementation by stakeholders involved in the construction and operation/maintenance phases of the building life cycle. There are very few (if any) strategies to be addressed by stakeholders such as government representatives, community members, demolition contractors, disposal agents, salvage agents, utility providers or financiers.

There is increasing evidence that physical environmental conditions may hinder or promote learning and appropriate behavior among students. Proponents of high performance school design suggest that implementing high performance strategies may improve academic performance. From a review of studies that evaluate impacts of various physical environmental conditions on learning and behavior, fifteen conditions were identified as having impacts. Of these, seven conditions were addressed by the majority of the guidance documents reviewed. These include electric lighting, daylighting, interior finishes, acoustics, temperature, relative humidity, and indoor air quality. There is a clear opportunity to incorporate research findings from the

environment behavior field into guidance documents to enhance learning environments in our schools.

While design guides play an important role in the creation of high performance facilities, they cannot, in their present state, be used to ensure that a building continues to perform as intended once the facility is delivered and occupied. Several documents recommend continuous building commissioning and/or post-occupancy evaluations. Without requiring these measures, the performance of these facilities may diminish. While there are many protocols for diagnosing buildings and for conducting post-occupancy evaluations, there is no simple, standard approach for ensuring that high performance buildings are actually high performing further down the road.

This is not to say that a design guide or similar guidance document should attempt to provide all of the necessary information to all of the stakeholders as well as procedures for ensuring that a building performs as intended well into the future. The guidance document itself is merely one tool for creating high performance schools. This study has shown that there are opportunities for developing additional types of information and tools to ensure that our schools are efficient, economical, and healthy with minimal or no adverse impacts on nature.

Despite an abundance of information and interest in high performance design, buildings in general (and schools in particular) seem to be getting more sustainable at a slow pace and in a limited number of locations. This type of design approach may be considered an innovation, although most recommended strategies have been available for many years. According to Everett Rogers (Rogers 1995), an innovation is defined as “an idea, practice, or object that is perceived as new by an individual or other unit of adoption”. According to his model, decisions about whether or not to adopt an innovation begin with knowledge about the existence of an innovation and how it functions. Secondly, there is persuasion, during which time an individual forms an opinion about the innovation (favorable or unfavorable). Guidance documents, because they include information about high performance design and construction, as well as associated benefits, may contribute to these two steps in the process. In the third phase, an individual does something that leads him or her to adopt or reject the innovation. Implementation occurs when the individual actually uses the innovation. Finally, the individual either seeks reinforcement of his or her decision or reverses the previous decision based on what has occurred. There are many variables that affect the rate of adoption (i.e., how quickly the use of an innovation increases), but the five steps of the innovation-decision process described above remain the same. It is not known whether or not design guides are effective in providing knowledge and persuading an individual (or group of individuals) to adopt high performance design and construction practices.

7.0 Research Needs

There is a plethora of information on how to create high performance facilities for schools and other building types. This information is available from numerous sources and via various types of media (print, web, etc.). Even for the researcher, finding relevant

information is challenging; it is not uncommon to get several thousand hits when entering a set of key words into a search engine. One important source of information is guidance documents such as those evaluated in this paper. The information in these guidance documents is organized using a wide variety of structures. Often, there appears to be a mismatch between the intended target audience and the organizational structure of these documents. It is not known if the way that we organize information impacts the ability of the target audience to comprehend and apply this information. There is a need for research to test whether or not various organizational structures impact comprehension by members of a target audience. It is likely that some of these documents have been more effective than others in promoting the design and delivery of high performance facilities. Research to ascertain which factors (e.g., organizational structure, language, type of information) have the most impact on knowledge and persuasion is also needed. Otherwise, national, state and local agencies will continue to develop new guides or modify existing ones without understanding what characteristics improve the likelihood of success for implementing recommended strategies.

This study has reviewed the guidance documents in terms of the types of information they contain and how this information is organized. However, a review of the accuracy and appropriateness of this information for intended stakeholders has not been conducted. Also, they have not been evaluated to assess the type and level of the language used to determine if these are appropriate for the target audience.

While the high performance design process relies on an integrated design approach, this is not the manner in which most school districts deliver facilities. There is a need to evaluate the effectiveness of these guides when used in a traditional, linear design process versus the type of integrated process many of the design guides recommend. Further, there is a need to assess whether or not design teams that use the design guides are more effective in creating a high performance school than those that do not.

The guidance documents are used primarily during design. We may declare a building as high performance, green or sustainable based on its design and construction. However, once occupied the building users may make changes that undermine those best efforts. There is no simple way to verify that the facility is performing as intended. Research to develop a tool that includes an assessment of building performance and post-occupancy evaluation could ensure that the facility goals continue to be met well into the latter phases of the building life cycle.

This study has shown that a wide variety of guidance documents exist to help facility decision-makers create high performance buildings. The organizational structures, the breadth and depth of the information, the types of benefits that are reported, the specific stakeholders addressed, the building life cycle phases addressed and other factors likely contribute to whether or not these documents are effective in providing the right information to the right stakeholders in the right format. This, in turn, may impact whether or not school districts are successful at adopting the procedures and strategies to deliver high performance facilities. There is a need for additional research to help answer these questions.

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Appendix A
Physical Environmental School Conditions and Student Performance: A Summary of Several Studies

Study	Research Questions/Hypothesis	Subjects	Physical/ Classroom Variables	Performance/ Behavioral/ Health Impacts	Major Findings
Ahrentzen, S. and G. W. Evans (1984)	<ul style="list-style-type: none"> - more open and nonpermanent structures on perimeter of classroom, greater distraction, less satisfaction - Spaciousness in classroom, less kinetic and visual distraction, and greater satisfaction - Modified activities to reduce noise in open classrooms - Private areas and desks, greater satisfaction and perceived privacy 	13 fourth, fifth and sixth grade teachers and 65 randomly selected students from 5 schools	Interior spaciousness, Perimeter, privacy amenities	Distraction, activity restrictions, privacy	<p>Distraction affects teachers more than students.</p> <p>Greater structural wall area, less distraction, greater satisfaction and less restriction of activities.</p> <p>Open perimeter - less kinetic distraction and more satisfied teacher.</p> <p>Students associate higher ceilings with more kinetic distraction, but less visual distraction.</p>
Bowers, J. H. and C. W. Burkett (1987)	Differences will exist between the new and old schools in achievement, disciplinary actions, health and attendance between new and old schools (better in new)	Two hundred eighty fourth and sixth grade students (some in a new and old school) to determine academic achievement.	Age of the school	Attendance, health, discipline, achievement	Higher achievement in math, reading, listening and language, fewer health problems, fewer discipline problems and higher attendance in new school
Cash, C. S. (1993)	Better building conditions will improve student achievement and behavior	rural schools in VA, 47 schools total	<p>Building condition: as determined by the Commonwealth Assessment of Physical Environment. These assessments were conducted by school personnel in the divisions of the schools</p>	Student Achievement: Scale scores of the Test of Academic Proficiency for grade 11; Student Behavior: number of expulsions, suspensions, and incidences of violence/ substance abuse compared to the number of total	Student achievement was higher in schools in better condition; Science achievement was higher in schools with better lab facilities; cosmetic conditions impact achievement more than structural conditions; "varying climate control, locker, and graffiti conditions were factors which were positively related to student achievement scale scores." Higher quality buildings were correlated to higher incidents of undesirable

Study	Research Questions/Hypothesis	Subjects	Physical/ Classroom Variables	Performance/ Behavioral/ Health Impacts	Major Findings
			the schools	students.	behavior.
Chan, T. C. (1980)	Physical conditions including AC, carpeting, fluorescent lighting and pastel colors affect student achievement.	8th grade students in 191 public standard schools in Georgia	<p>presence or absence of</p> <ol style="list-style-type: none"> 1. air conditioning 2. carpet 3. fluorescent lighting 4. interior pastel coloring 	academic achievement, as measured by scores on the Iowa Test of Basic Skills (1975-1976)	<p>Vocabulary scores for students were higher in air-conditioned schools when compared to non-air conditioned schools. No difference was found in the composite, reading, language, work-study and mathematics sections of the ITBS; No significant differences were observed in academic achievement were observed for the presence or absence of fluorescent lighting, carpeting or pastel coloring.</p>
Chan, T.C. (1982)	Is there a difference in student attitude toward a new and old school; Are there differences in attitude according to race, sex, socio-economic status?	<p>Control group= 119 students (grades 2,3,4) in an old school building (1936)</p> <p>Experimental group = 96 students (grades 2,3,4) in an old school building (1923) who were moved to a new school (1980)</p>	building-condition related variables, including age	attitude	<p>More positive attitudes towards the newer school; Females had higher ratings than males in the control group, but no difference in experimental group; Race, SES "had no effect on pupil attitudes toward school buildings."</p>

Study	Research Questions/Hypothesis	Subjects	Physical/ Classroom Variables	Performance/ Behavioral/ Health Impacts	Major Findings
Cheng, Y.C. (1994)	Is there a relationship between "student affective performance and classroom physical environment, social climate, and management style?"	21,622 students from 678 classes of mainly sixth-grade students in 190 sampled primary schools	include 11 items to assess the quality of the physical environment in the classroom including physical facilities, cleanliness, spacing, neatness and a lack of pollution. Student perceptions are used to evaluate these physical conditions; Class master's leader behavior; Use of power; Social climate in the classroom	Individual student affective performance (self-concept, attitudes toward peers, attitudes toward school, attitudes toward teachers, self-efficacy of learning, feeling of homework overload and intention to drop out).	quality of physical environment, social climate, and class master's management style related substantially to nearly all the measures of student affective performance except self-concept."
Christie, D. J. and C. D. Glickman (1980)	How does noise level affect student intellectual performance? As children age, they will be better at ignoring distracting noise.	156 children from a public school in Central Ohio. All of the children were from traditional self-contained classrooms	noise level	Achievement on Standard Progressive matrices	"Children's performance on the Standard Progressive Matrix task increased consistently with age." "the current research offers evidence for the notion that boys are able to solve more complex matrix problems in a noisy environment." "Females tend to perform higher in a quiet rather than noisy environment." "the effects of classroom noise do not vary with age."
Cohen, S. and S. L. Trostle (1990)	What are the preferences of school-aged children for physical environmental	78 kindergarten and 1st-grade children in public schools.	size, shape, color, complexity, texture, lighting, as presented	Preferences	Girls had mean scores higher than boys for complexity, color, texture and lighting. Boys

Study	Research Questions/Hypothesis	Subjects	Physical/ Classroom Variables	Performance/ Behavioral/ Health Impacts	Major Findings
	features of a school?		on test cards for a “pretend” school and school yard		preferred larger features. Older children preferred multi-shaped objects, complex items and more dramatic colors, as well as more intense lighting than younger children, who also preferred larger characteristics.
Cotterell, J. L. (1984)	Lower student anxiety expected in open school; Lower anxiety in low conceptual level Students anticipated	142 intake students from 4 suburban high schools, 2 open and 2 conventional,	Open vs. closed school plan	Student personality (CL); Classroom; Student Behavior; Anxiety	“Students in open plan high schools, compared with those in high schools of conventional design, experienced less initial anxiety pertaining to locating school buildings, but greater anxiety within the classroom. Observations found greater amounts of student off-task behavior in open plan classrooms, and higher rates of managerial intervention by teachers in the transitions from one activity to another.”
Edwards, M. M. (1991)	1. Does parental involvement impact building conditions? 2. Do building conditions impacts student achievement?	Uses 2 data sets – a larger set, and a subset of 52 schools that were surveyed – all in the Washington DC area.	Size of Parent Teacher Association budget, Overall condition of school building	Academic achievement	Age predicts building conditions; Higher enrollment related to better building conditions; Higher PTA budget correlated with improved building conditions; as income in surrounding area increased, so does building condition; Improvement in building condition is associated with improved student achievement.
Evans, G. W. and L. Maxwell (1997)	1. Does language acquisition act as a mediator between noise exposure and reading deficits? 2. Is short (acute) or long-term (chronic) exposure to noise contributing to reading problems?	116 first and second graders (53% female), for whom English is their first language, from 2 elementary, predominantly Black schools in New York City	Noise: Inside or outside a 65 Leq flight contour	Reading skills; language acquisition (speech and sound perception)	chronic noise exposure is correlated with reading scores. Speech perception, not sound perception, acts as a partial mediator.

Study	Research Questions/Hypothesis	Subjects	Physical/ Classroom Variables	Performance/ Behavioral/ Health Impacts	Major Findings
Grandgaard, E. M. (1995)	What is the effect (behavioral and physiological) of color and light on young children?	five 6-yr old boys and six 6-yr old girls in a public school.	white walls and cool-white fluorescent lights versus light blue walls and full-spectrum lighting	Off-task behavior; mean blood pressure	"The study found that the students accumulated a total of 390 off-task behaviors in the standard classroom compared to 310 in the modified classroom, a decrease of 22 percent. It also found that students' mean blood pressure readings were nine percent lower in the modified classroom when compared to their readings in the standard classroom."
Heschong Mahone Group (1999)	Daylighting from windows or skylights will impact student performance	21,000 students from 3 school districts	demographics, window tint and size, presence and type of skylights, amount of daylight expected.	test scores in math and reading (unclear what test was used)	"students with the most daylighting in their classrooms progressed 20% faster on math tests and 26% on reading test in one year than those with the least. Similarly, students in classrooms with the largest window areas were found to progress 15% faster in math and 23% faster in reading than those with the least. And students that had a well-designed skylight in their room, one that diffused the daylight throughout the room, also improved 19-20% faster than those students without a skylight. We also identified another window-related effect, in that students in classrooms where windows could be opened were found to progress 7-8% faster than those in rooms

Study	Research Questions/Hypothesis	Subjects	Physical/ Classroom Variables	Performance/ Behavioral/ Health Impacts	Major Findings
					with fixed windows.
Hood-Smith, N. E. and R. J. Leffingwell (1983)	What are "the effects of the rearrangement of the desks in an open classroom on the incidents of disruptive behavior occurring in that classroom"?	Students in one disruptive classroom in a secondary school	Furniture arrangement	Various behaviors, observed before and after modifications	Teacher felt more in control; students were more comfortable, felt less threatened and were more willing to interact with one another; actual class work time increased; class members were better able to interact with the teacher;
Lackney, J. A. (1996)	<ol style="list-style-type: none"> 1. "What is the perception of the nature of environmental quality within the context of schools?" 2. "Within the context of schools, what are the attributes of environmental quality that are perceived to have an impact on educational outcomes?" 3. "What perceived impact does facility management have, if any, on the perception of environmental quality in schools?" 4. "How can environment-behavior research contribute to the improvement of the environmental quality in schools?" 5. How can environmental quality be assessed in local school contexts?" 6. "How effective is action research in defining problems, providing solutions and increasing knowledge and awareness of environmental 	Parents, teachers, students, administrators, non-instructional staff	physical comfort and health, classroom adaptability, safety and security, building functionality, aesthetics and appearance, (environmental perceptions of students and environmental quality concerns of both teachers and students were included)	"perceived differences in environmental quality, facility management processes and practices and three educational outcome indicators: student academic performance, student social development and teacher instructional performance."	<ol style="list-style-type: none"> 1. action research is an appropriate tool for learning about environmental features that matter the most to school stakeholders. 2. school building occupants perceive that several physical features affect educational outcomes, particularly physical comfort and health, and classroom adaptability impacts on student and teacher performance.

Study	Research Questions/Hypothesis	Subjects	Physical/ Classroom Variables	Performance/ Behavioral/ Health Impacts	Major Findings
	quality in schools?"				
Ott, J. N. (1976)	Does lighting affect student behavior?	1st grade children in 4 different windowless classrooms.	standard cool-white fluorescent tubes and fixtures with solid plastic diffusers (2 rooms) versus full-spectrum fluorescent tubes with lead foil shields on the ends of the tubes.	Observed behaviors (no specific behaviors sought)	Children in the room with standard lighting were more fidgety, and seen "leaping from their seats, flailing their arms, and paying little attention to their teachers". Those in the full-spectrum lit rooms were less nervous and paid more attention to the teacher.
Winett, R. A., C. D. Battersby, et al. (1975)	What effects will architectural changes, individualized instruction, and group contingencies on academic work have on student performance in math and language and on behavior?	27 children in a 6th grade public school classroom from a wide range of ability and socioeconomic levels. Only 10 children were observed for behavior.	The architectural intervention consisted of swapping one-piece chair-desks with desks with movable chairs arranged in four groups of eight. Other smaller changes were also made. The changes allowed students to work in groups of heterogeneous ability. (There were other non-arch. Modifications made during the study)	Behavioral observations measured eight children activities (e.g., working independently, interacting with teacher). Four codes pertained to children's communication. Several teacher instructional codes included. Academic work was measured for completion and accuracy for math and language assignments.	"Individualized instruction along had lesser effects, while the architectural changes produced no significant changes in the academic or social behavior of the children or in teacher behaviors."

Study	Research Questions/Hypothesis	Subjects	Physical/ Classroom Variables	Performance/ Behavioral/ Health Impacts	Major Findings
Wollin, D. D. and M. Montagne (1981)	<p>"an amiable classroom environment would beneficially affect human performance and interaction. H1: Specifically, it was hypothesized that improved learning would occur in a congenial room."</p> <p>H2: "Student evaluation of the teacher would be more positive and that there would be increased interaction between teacher and students in the experimental room."</p> <p>H3: "Student (user) attitudes toward the experimental room would be more positive than toward the control room and vandalism to the experimental room would be minimal."</p>	Students in 2 introductory Psychology college classes	Interior décor – carpet, plants, furniture, paint, etc.	student scores on tests, student evaluation of the teacher, amount of teacher-student interaction, student reaction to a direct questionnaire inquiring about the room décor, and the amount of vandalism or theft in the experimental room	<p>"The conclusion drawn here is that improving the interior of public buildings in general and college classrooms in particular can have a very beneficial effect on the activity therein. Students perform significantly better on academic tests taken in a congenial room, and they see their teachers in a much more favorable light. The teachers themselves may actually improve their teaching performance in a congenial environment." No significant differences were observed for vandalism or teacher-student interaction."</p>
Downing, C. C. and C. Bayer (1993)	Purpose is to provide a comparison of indoor pollutant concentrations under different outdoor air ventilation rates.	students and employees at an elementary school (only complaints were recorded). Conditions in 3 classrooms were compared.	presence or absence of a total energy recovery wheel system to control humidity. (many measurements were taken)	Number of complaints and results from 4 interview with school staff about problems they experienced before and after intervention	<p>"Implementation of the ventilation rate procedure of ANSI/ASHRAE 62-1989 to achieve 15 cfm (7.5 l/s) per student in classrooms is necessary to reduce CO2 levels below the 1,000-ppm guideline. Reductions in other pollutant levels, including VOCs and formaldehyde, ranged between 28% and 60% at the ventilation rate of 15 cfm/student"</p>

Study	Research Questions/Hypothesis	Subjects	Physical/ Classroom Variables	Performance/ Behavioral/ Health Impacts	Major Findings
Fischer, J. (1996)	"the majority of IAQ problems experienced by school facilities occur as a result of inadequate outdoor air and/or lack of humidity control"	Students and teachers in 8 schools in which serious IAQ problems had been addressed and resolved by incorporating a total energy recovery system.	Type of retrofit equipment, costs, Hydrocarbon contaminant levels, relative humidity,	complaints from students and employees	"Based on established research, the free humidification provided by the total energy recovery technology will reduce the incidence of respiratory illness and absenteeism in the classroom environment, especially in colder climates." "inadequate outdoor air and/or lack of humidity control are the cause of, or at the very least primary contributors to, most IAQ problems encountered by schools."
Green, G. H. (1974)	Reviews 3 studies	kindergarten children in Switzerland	Humidity, temperature	Reported symptoms of the common cold (e.g., sneezing, coughing, sore throat, fever)	"It shows that 3% (test unit) and 5.7% (control unit) of the total maximum study days were absent. These results seem to indicate that an increase in relative humidity from 40% to approximately 50% is favorable under the given conditions."

Study	Research Questions/Hypothesis	Subjects	Physical/ Classroom Variables	Performance/ Behavioral/ Health Impacts	Major Findings
Green, G. H. (1974)	Reviews 3 studies	Canadian school students in 6 schools (plus 6 more in the later part of the study)	Temperature, relative humidity	Absenteeism and associated records with explanations for absences	"When the schools in the Canadian investigation were divided into humidified and unhumidified groups, the average 10-year absenteeism in the unhumidified schools was found to be 5.08 % and in the humidified schools 4.63%, values which differ at the 95% confidence level."
Rindel, A., E. Bach, et al. (1987)	"the presence of readily visible man-made mineral-fiber (MMMf) products in the ceiling should be mainly responsible for the occurrence of symptoms and/or disease related to indoor exposure in kindergartens.	Approximately 900 children and 200 adults in 24 kindergartens in Frederiksborg County, Denmark. The facilities were built in the 1970's, did not have wall-to-wall carpeting, and had no fresh air supplied by mechanical means.	The buildings were assigned to one of 3 categories including, A. MMMf-products with water-soluble binders in the ceiling B. MMMf-products with resin-binders in ceilings C. No readily visible MMMf-products in the ceilings (control), included 8 facilities. Data from a number of indoor environment parameters were collected (e.g., air concentration of VOCs and formaldehyde, air exchange rates, airborne MMMf concentrations, etc.) .	a host of symptom-related information (e.g., irritation of eyes, nose, throat and skin, headaches, tiredness, dizziness, nausea, inflammatory disease, colds, sinusitis, angina and pneumonia) was collected.	"symptoms from eyes and skin were reported more frequently in A and B institutions than in control institutions. The frequencies of diseases and symptoms were uniformly distributed in A and B institutions." "On their own, the technical investigations do not indicate that the symptoms are caused by MMMFs derived from the ceilings." For adults, however, the average concentrations of airborne MMMFs were positively correlated to eye symptoms, and the presence of settled MMMFs on surfaces occasionally cleaned were positively correlated to skin irritation."

Appendix B

High-Performance Schools: Assistance Programs, Case Studies and Web Links

The following is a listing of national and state assistance programs, case study examples, and web resources to assist school system with creating high-performance schools. This is not a comprehensive list.

Assistance Programs

National and state assistance programs, such as those listed below, may provide information, technical assistance, grants, equipment, recognition, awards and other incentives for high-performance schools. The preponderance of these programs address energy efficiency, one aspect of high-performance schools. Some programs also provide information and assistance on a broader range of high-performance issues. Those listed below are a sample of assistance programs and is not intended to be a comprehensive list.

National Assistance Programs

Alliance to Save Energy's Green Schools Program

(www.ase.org/greenschools/index.htm): The Alliance to Save Energy is a non-profit coalition comprised of business, government, environmental, and consumer leaders. Energy conservation in schools is the primary focus of this program. It actively involves students in establishing an energy use baseline and identifying needed retrofits and behavioral changes to reduce energy consumption. Free lesson plans to incorporate energy concepts into the curriculum are provided, as well as links to other free materials and some that are available for a fee. The program also encourages teamwork between the school, school district, local organizations, and businesses. At least eighteen schools have participated in the program, with positive results.

Schools Going Solar (www.irecusa.org/schools/): A project of the Interstate Renewable Energy Council (IREC), this web site provides information and links on solar energy and how it can and has been used in schools. The purpose of this project is to create a network of people involved with solar schools to assist those seeking to implement solar projects. The Database of State Incentives for Renewable Energy on this site allows one to search for schools that have incorporated solar technologies, complete with project summaries and points of contact for additional information.

Sustainable Buildings Industry Council (SBIC)

(www.sbicouncil.org/workshops/schools.htm): This group has organized workshops for California school-related personnel regarding sustainable schools that may become models for other states to adopt. Additionally, the SBIC works with states to assist them with updating design and construction documents and to educate appropriate people about high-performance schools.

Energy Smart Schools, Department of Energy (www.eren.doe.gov/energysmartschools):

This campaign is operated by the Rebuild America program of the U.S. Department of

Energy. Participating schools may receive training workshops, recognition, and access to partners to help them in their efforts. The campaign also creates and compiles teacher materials and available lesson plans. The building resources available on the website include guidance documents to assist schools with new school design, renovations, operations and maintenance, and selecting appropriate building technologies. There are a variety of ways in which a school can become involved with Energy Smart Schools. In Albuquerque, New Mexico, the Rio Grande High School received lighting retrofits in four classrooms at no cost to the school, funded by four Rebuild America partners, to demonstrate natural lighting and associated energy efficiency. In these classrooms, little artificial lighting is needed.

Energy Star Buildings (www.energystar.gov): This program provides a tool for benchmarking a school building to see how it compares with similar buildings across the country with respect to energy performance. Those schools that rank in the top 25% of similar schools can earn the Energy Star label, a bronze plaque signifying their accomplishments. An example is the Wilson Middle School in Wayandotte, Michigan with 10 buildings that have been awarded the Energy Star Building label (Fracassa 2001). The Kingston School District (NY) is also among those that have received the Energy Star award for energy efficiency upgrades (Kennedy 2001).

EPA Tools for Schools (www.epa.gov/iaq/schools/): This initiative of the U.S. Environmental Protection Agency aims to prevent, identify and resolve indoor air quality problems in the schools by actively involving schools in the program. Free kits are available to those seeking to implement a program to improve indoor air quality. Awards are given each year (since 2000) to those actively involved with the program.

State Assistance Programs

Collaborative for High-performance Schools (CHPS) (www.chps.net): This is a collaborative of government, utilities and non-profit representatives with the goal to “improve the quality of education for California’s children and facilitate the design of learning environments that are resource efficient, healthy, comfortable, well-lit, and contain the amenities needed for a quality education”. The *Best Practices Manual* is available to assist designers and school districts with designing, constructing and operating high-performance schools. A point-based rating tool has also been developed to evaluate school facilities. Schools that earn at least 28 out of 81 available points can be certified as a CHPS school.

New Jersey Sustainable Schools Network

(<http://community.nj.com/cc/sustainableschools>): Schools and a host of other organizations have formed this consortium to promote sustainability education. The current emphasis is to assist model green schools in New Jersey.

California Bright Schools Program www.energy.ca.gov/efficiency/brightschoools

Schools in the state of California receive technical assistance from the California Energy Commission with the identification, design and implementation of energy efficient

strategies, including assistance with obtaining loans for projects, at no cost to school systems. A school submits an application describing the type of assistance it would like to receive. Assistance is limited by the availability of budgeted funds.

Sun4Schools Project: (www.montanagreenpower.org/solar/schools/sun4schools.html).

The National Center for Appropriate Technology assists with administering the program. Twelve schools received 2 kilowatt photovoltaic systems that generate approximately 3000 kilowatt hours of electricity per year, funded by the Montana Power Company' Universal System Benefits Charge.

Partnership for Resource-Efficient Schools, Seattle, Washington: The partnership has two primary goals including 1) to show City support for the Building Excellence Program; and 2) to influence change in design and construction practices; to demonstrate schools can be built sustainably. The Partnership encourages sustainable design, construction, and operation of Seattle schools. The Building Excellence Program was established following a 1995, \$357 million school levy to lead the way for this capital campaign for schools. The Program is intended to ensure that economic responsibility and the provision of optimal learning environments are considered.

Case Studies

In addition to assistance programs, several schools have incorporated sustainable building strategies to varying degrees and serve as models from which others can learn. The following case studies have been compiled from various sources. Unfortunately, while these and other case studies demonstrate the many benefits of high-performance school design, case study information is scattered and there is no standardized format for reporting the data. Also, there is typically little information provided as to how the numbers for cost savings or other results were calculated or derived. Again, this is not intended to be a comprehensive list, rather examples of success stories.

The Sonoji Saki Intermediate School, located in the Bainbridge Island School District in Washington State and occupied in January 2000, is one example. The school board established 3 sustainability-related goals for the school early in the project that included minimally impacting ecosystems, ensuring good indoor air quality and conserving resources. Sustainable strategies included sedimentation minimization during construction, watershed protection through stormwater management, banning pesticide use, replanting natural vegetation, and specifying higher than required ventilation rates (20cfm/person), low and non-toxic finishes, and recycled content products. The school also has displayed 2 signs describing the sustainable features of the building, and green building topics have been included into the curriculum design (Pollution Prevention Resource Center 2001).

McKinney, Texas: The Roy Lee Walker Elementary School is considered one of the most sustainable schools in the country (Fratt 2001)Fratt 2001). The energy-efficient design incorporates a daylighting strategy using baffles to bounce natural light into the building. Up to 68,000 gallons of rainwater are collected in cisterns for use in irrigation, lowering

water bills substantially compared to other schools. The carpet inside the building is recyclable and will be returned to its manufacturer for recycling after approximately 15 years of use, keeping more than 39,000 pounds of carpet out of a landfill. A windmill supplies power for circulating water from cisterns to the irrigation system and solar panels generates a portion of the school's energy requirements. The building was approximately \$1 million more expensive to build than a typical school of similar size, although it has been estimated that these costs will be recovered in 7-10 years due to savings in operation and maintenance

Raleigh, North Carolina: Durant Road Middle School is often cited as a successful example of a high-performance school, particularly for its daylighting strategies. The school opened in 1995 and cost \$12.3 million, less than the amount budgeted for it. Energy savings of approximately \$77,000 per year have been realized, when compared to the average school meeting the same ventilation standards and operating approximately 10 months out of the year. The daylighting is thought to contribute to higher attendance. Wake County had the highest attendance rate among the 100 schools in the district in 1996, averaging around 98% versus 95% county-wide (Innovative Design 2001).

Raleigh, North Carolina: The Ravenscroft School underwent a major renovation that cost \$1.4 million to improve the building shell, incorporate daylighting strategies and install a solar pool heating and hot water system. Approximately \$93,000 annually is saved from reduced energy consumption (Innovative Design 2001)

Johnston County, North Carolina: Two middle schools with daylighting were built in 1993. A prototype design was used and modified for the Selma Middle School (98,000 sf) and the Clayton Middle School (120,000 sf). The county has realized savings of more than \$500,000 since their completion. Two daylit elementary schools have also been built in Johnston County, Four Oaks Elementary, the first daylit school in the county (120,000 sf) and East Clayton Elementary (96,800 sf) (Innovative Design 2001).

Fort Collins, Colorado: The Johnson Elementary School has incorporated high-performance, green design elements into its facility into the HVAC and lighting systems, the building site, and classroom design (CEFPI 2001).

Los Angeles, CA: With the help of the Department of Water and Power have planted 8,000 trees on school campuses to reduce electricity costs and reduce flooding (Kennedy 2001).

Forest City and Akron-Westfield community schools, Iowa: These schools are using wind turbines to supply a portion of their power needs [Kennedy, 2001 #96].

Washington County, TN: Daniel Boone High School saved \$82,000 on energy costs by using geothermal heating and cooling (Dentch 2000; Reicher 2000). The heat pump was installed in the 1995-96 school year to replace a system that used electricity to heat the school and a two-pipe chilled water system for cooling, saving \$62,000 during the first complete year of operation (Innovative Design 2001).

West Jordan, Utah: Oquirrh Hills Elementary School was rebuilt after a fire destroyed it in 1995. The new school (61,200 sf) incorporates low-emissivity windows, light-colored interiors, a light colored roof with R-30 insulation, T-8 fluorescent lighting with electronic ballasts, and an energy management system. Operation costs are approximately \$22,000 less than the original building, which was located on the same foundation (Innovative Design 2001).

Minneapolis, Minnesota: The Interdistrict Downtown School, a magnet school with 520 Kindergarten through twelfth graders, extensively uses solar heating via a 2,115 square foot solar wall system, saving about \$5,600 annually. It is not uncommon for the active solar collector to preheat outside air by 30° F on an average winter day (Innovative Design 2001).

Spirit Lake, Iowa: Spirit Lake Elementary School boasts a wind turbine on its lawn that generates an average of 288,670 kilowatt hours of electricity annually. Operating since 1993, the turbine has generated enough power naturally to eliminate more than 3 million pounds of carbon dioxide and more than 400,000 pounds of sulfur dioxide that would have been produced using fossil fuel based energy sources. Students can monitor wind production and calculate positive environmental impacts (Innovative Design 2001).

Worthington, Ohio: Bluffsvie Elementary School has installed a 2-kilowatt photovoltaic system that was purchased and installed using \$20,000 as a part of the Million Solar Roofs Initiative of the U.S. Department of Energy. Students can see how the system works, monitor the amount of energy produced by the panel and compare energy produced to energy consumed by the building using an Internet link through the American Electric Power's Datapult system (Innovative Design 2001).

Cambridge, MD: Choptank Elementary Schools anticipates savings of \$400,000 over a 20 year period as a result of using a geothermal heat pump for 45,000 square feet of building space conditioning (SBIC 2001).

Web Resources

- Energy Quest www.energy.ca.gov/education
- SolarQuest www.solarquest.com
- Solar Now www.eren.doe.gov/solarnow/solarnow.htm
- Solar Schools www.eren.doe.gov/solarschools
- Watts on Schools www.wattsonschoools.com
- Schools Going Solar www.ttcorp.com/upvg/schools/index
- Bright Schools Program (California Energy Commission) www.energy.ca.gov/efficiency/brightschoools/
- Million Solar Roofs Campaign, Department of Energy: [web site] [describe]:
- Department of Energy, Energy Smart Schools Campaign www.eren.doe.gov/energysmartschools

- Rebuild America www.rebuild.org
 - Department of Energy, Energy Star Buildings Program www.energystar.gov
 - Sustainable Building Industry Council www.SBICouncil.org
 - American Institute of Architects, Los Angeles www.aialosangeles.org
 - American Institute of Architects, Orange County www.aiaoc.org
 - American Solar Energy Society www.ases.org/solarguide
 - Collaborative for High-Performance Schools www.CHPS.net
 - U.S. Green Building Council www.usgbc.org
 - Whole Building Design Guide www.wbdg.org
 - Green Schools Program (Alliance to Save Energy) www.ase.org/greenschools
 - California Energy Commission
www.consumerenergycenter.org/schools/high_performance.html
 - Green Building Articles/Publications, Center of Excellence for Sustainable Development, U.S. Department of Energy
<http://www.sustainable.doe.gov/buildings/gbarttoc.shtml>
 - National Clearinghouse for Educational Facilities (extensive list of resources on high-performance schools) www.edfacilities.org/ir/high_performance.cfm
 - Department of Energy, Center of Excellence for Sustainable Development
www.sustainable.doe.gov
 - Second Nature, works with colleges and universities to become more sustainable
www.secondnature.org
 - Environmental Protection Agency, Indoor Air Quality www.epa.gov/iaq
-
- *Case Studies*
 - Pollution Prevention Resources Center www.pprc.org [verify]
 - SHW Group Architect www.shwgroup.com/walker/timeline.html
 - Sustainable Schools www.innovativedesign.net
 - The Way to Go: Case studies in North Carolina, including some schools.
<http://www.sustainablenc.org/thewaytogo/main/cases.htm>