Sustainability in Public Facilities: Analysis of Guidance Documents

Sheila J. Bosch[1] and Annie R. Pearce, M.ASCE[2]

Abstract: With increasing evidence that sustainable design and construction results in more energy-efficient, lower-cost, less environmentally damaging, and more occupant-friendly facilities, organizations have begun to seek guidance on integrating concepts of sustainability into their capital programs. A growing number of guidance documents have been developed to support these sustainability efforts. While these documents contain a broad spectrum of information on sustainable buildings, they are not necessarily written or organized suitably for stakeholders associated with the postconstruction phases of the facility life cycle. This paper presents a critical parametric analysis of nine such documents intended to educate facility decision makers on sustainability. The analysis revealed that these documents, with some exceptions, do not address all of their intended audiences equally, with most information focusing on designers and owners and comparatively less information targeted to others such as facilities managers. Given the crucial role facilities managers play in ensuring the ongoing sustainable performance of facilities, there is a need to modify or extend existing guidance documents to better address the needs of facilities managers.

DOI: 10.1061/(ASCE)0887-3828(2003)17:1(1)

CE Database keywords: Buildings, public; Schools; Building design; Construction; Documentation; Facilities; Management.

Introduction and Background

Building stakeholders, from owners to designers to constructors and facilities managers, are showing a growing interest in sustainable or high performance building practices as increasing evidence suggests that they can result in buildings that improve academic performance and student behavior (in schools), increase employee satisfaction, productivity, health, and retention, and reduce absenteeism (Green 1974; Hechong Mahone Group 1999; Menzies et al. 1997; Arnoff and Kaplan 1995; Becker and Steele 1995). Additional benefits of sustainable practices include energy, water, and other resource savings over the facility life cycle, reduced environmental liability and impact, and even first-cost savings (City of New York 1999; Kobet et al. 1999; Unger et al. 2000; University of Minnesota 2000; Collaborative for High Performance Schools 2001; Innovative Design 2001; Triangle J Council of Governments 2001; U.S. Green Building Council 2001). Stakeholders have begun to consider sustainability as a realistic and beneficial goal for their capital facilities, one that will result in better-performing buildings with reduced demands on infrastructure and lower maintenance requirements.

In response to increasing demand among public institutions and private organizations alike for guidance and information on sustainable capital projects, a growing number of reference documents is being developed and utilized by built environment stakeholders as a means of improving both the *process* by which capital projects are delivered and the *technologies, products, and design elements* that together compose the resulting capital project. Despite this evolving volume of information on sustainable buildings and well-documented benefits, however, the diffusion of sustainable practices and exemplar projects in the United States is not as rapid as might be expected. One possible explanation is that these documents may not address equally well the concerns of and opportunities available to all stakeholders throughout the building life cycle. For example, one prior study (Jones-Crabtree et al. 1998) found that much of the information available in sustainable building checklists is focused on the building design phase of the life cycle, while information is comparatively sparse for other phases. In particular, sustainability knowledge specifically targeted to facilities managers is nonexistent. The only way many documents even include facilities managers is as part of an integrated design approach.

An integrated design approach is considered essential for ensuring that projects successfully incorporate sustainable strategies (USGBC 2001; University of Minnesota 2000; Kobet et al. 1999). Using this approach, stakeholders such as facilities managers, operation and maintenance staff, and even members of the local community are involved in the design process as early as the preplanning phase to ensure that sustainability goals are achieved. The active participation of facilities managers during the planning, design, and construction phases can ensure that sustainable strategies are not undermined after the facility is delivered. But this participation may not fully realize the potential of facilities managers to influence the sustainability of the resulting building. Facilities managers play a crucial role in ensuring that buildings deemed to be sustainable at the end of the construction process

[1]Shackelford Fellow, Sustainable Facilities & Infrastructure Branch, Georgia Tech Research Inst., 151 Sixth St., Suite 017, Atlanta, GA 30332-0837. E-mail: sheila.bosch@gtri.gatech.edu

[2]Branch Head, Sustainable Facilities & Infrastructure Branch, Georgia Tech Research Inst., 151 Sixth St., Suite 017, Atlanta, GA 30332-0837. E-mail: annie.pearce@gtri.gatech.edu

Note. Discussion open until July 1, 2003. Separate discussions must be submitted for individual papers. To extend the closing date by one month, a written request must be filed with the ASCE Managing Editor. The manuscript for this paper was submitted for review and possible publication on February 20, 2002; approved on August 27, 2002. This paper is part of the ***Journal of Performance of Constructed Facilities***, Vol. 17, No. 1, February 1, 2003. ©ASCE, ISSN 0887-3828/2003/1-1–10/$18.00.

Table 1. Guidance Documents Analyzed

Abbreviation/title	Author/publisher	Availability/comments
PSD—Poudre School District Sustainable Design Guidelines	The Poudre School District, Colo. (Unger et al. 2000)	www.psd.k12.co.us/district/construction
CHPS—Best Practices Manual, Volumes I, II, and III	Collaborative for High Performance Schools, Calif. (2001)	www.CHPS.net Includes a rating system
ID—Sustainable schools	Innovative Design (2001)	www.innovativedesign.net/sust-schools-guide.htm
SPS—Seattle Public Schools Partnership for Resource-Efficient Schools: Recommended Best Management Practices	City of Seattle and Seattle Public Schools, Wash (1998)	www.ci.seattle.wa.us/util/rescons/susbuild/docs/Resource.PDF
TJCoG—Triangle J Council of Governments High Performance Guidelines: Triangle Region Public Facilities	Triangle J Council of Governments, N.C. (2001)	www.tjcog.dst.nc.us/hpgtrpf.htm Includes a rating system
LEED—Leadership in Energy and Environmental Design Green Building Rating System	U.S. Green Building Council (2000)	www.usgbc.org Includes a rating system
PA—Commonwealth of Pennsylvania Guidelines for Creating High Performance Green Buildings	Commonwealth of Pennsylvania (Kobet et al. 1999)	www.gggc.state.pa.us/publictn/gbguides.html
NYC—City of New York High Performance Building Guidelines	City of New York, N.Y. (1999)	www.ci.nyc.ny.us/nyclink/html/ddc/home.html
MN—Minnesota Sustainable Design Guide	University of Minnesota (2000)	www.sustainabledesignguide.umn.edu Includes a rating system

continue to perform as intended during the operation and maintenance phase of the building life cycle.

The purpose of this paper is to examine the utility of current guidance documents for meeting the needs of facilities managers. Specific objectives include

- To highlight gaps within the current knowledge base
- To establish the coverage of existing knowledge
- To provide a means to guide facilities managers and other stakeholders in finding guidance documents that may be most useful in their situations
- To identify opportunities for future research

The contribution of the paper is to establish a starting point for further evaluation by characterizing a sample of sustainability guidance documents in terms of their goals, organizational structure, stakeholders, building life-cycle phases, and physical environmental conditions. This characterization identifies gaps, opportunities, and inconsistencies in how information is organized across the sample of documents analyzed, and provides a basis for evaluating the balance of such documents in terms of their coverage of information appropriate for each stakeholder in the target audience.

Methodology

The overall approach used in this study involved the following: selecting a sample of sustainable facility guidance documents; mapping attributes of those documents in terms of parameters that characterize capital projects and their life cycles; and drawing conclusions based on the gaps identified in the mappings. To provide a point of reference in terms of how guidance documents are intended to be used, the scope of this study focused on one important facility type in the institutional construction sector: schools. School systems across the United States are struggling to build new schools and renovate aging ones to accommodate increasing enrollments and new technologies. The condition of many schools in the U.S. is less than desirable. Approximately $127 billion is needed to bring schools up to good overall condition (Lewis et al. 2000). 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 or sustainable schools. This study examined a total of nine guidelines for sustainable facilities, all of which are applicable to school facilities and four of which were designed specifically for schools. Table 1 lists the guidance documents examined in this study.

Document Selection

Schools across the U.S. have used various design guides and other guidance documents to assist them with creating high performance, sustainable schools. Each of the high performance guidance documents evaluated in this study were developed in the U.S. They have been selected for evaluation because each document was either written specifically to aid school stakeholders in developing high performance or sustainable capital projects, or referenced by other documents or Web sites that serve as resources for 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, which includes recommended actions for most phases of the building life cycle for each high-performance strategy included in the document. Guidance documents fall within one of five primary categories of built environment sustainability literature, with a primary audience of practitioners (Pearce and Vanegas 2002). The nine selected sources represent the spectrum of guidance documents available in the U.S. for public facilities.

Data Extraction and Mapping Representation

After documents had been selected for analysis, the next step was to establish a consistent approach for characterizing the attributes

Table 2. Goals Expressed in Guidance Documents

Explicitly Stated Goals	PSD	CHPS	ID	SPS	TJCoG[c]	LEED	PA	NYC	MN[c]
Illustrate high performance design strategies	X			X					
Encourage change to create high performance buildings		X			X		X		
Inform stakeholders			X				X	X	X
Provide a framework for design and construction	X				X				
Help professionals exercise due diligence					X				
Facilitate input from stakeholders								X	
Help stakeholders understand their roles in the process								X	
Provide flexibility for setting priorities and measuring outcomes									X
Rate buildings		X[a]			X[a]	X			X[a]
Develop a decision-making process with measurable outcomes									X
Create a resource that can easily change									X

[a]While these do not explicitly state that rating buildings is a goal, these do contain rating systems.

of each document in terms of key parameters relevant to industry practice. Five key parameters were identified that can be used to compare the content and coverage of documents in terms of standard industry practice:

- *Goals*. What explicitly stated goals were identified by the authors of each document to guide how the document is intended to be used in practice?
- *Organizational structure*. How is the document organized in terms of section and subsection breakdowns to facilitate retrieval of specific information? Is any key provided to aid navigation by the reader?
- *Stakeholders*. What kinds of building stakeholders are either explicitly or implicitly identified by the authors as intended readers or users of the document?
- *Building life-cycle phases*. Based on the recommendations included in the document, which phases of the project life cycle (from predesign phases through operations, maintenance, rehabilitation, and end of life cycle) are covered by the document's contents?
- *Physical environmental conditions*. Based on the recommendations included in the document, what kinds of physical building attributes or systems are covered in the documents? In particular, how do the documents map onto conditions identified in the body of empirical knowledge as being important for human performance and sustainability?

For stakeholders, building life-cycle phases, and physical environmental conditions, standard classifications were derived from the literature to serve as a template for mapping each document's content. Each of these classifications is described in more detail in the next section. Most of the documents reviewed contain introductory sections in which the authors explain the goals or intended use of the document and explicitly identify its intended audience. The organizational structure of the document can then be derived from the headings and subheadings used to organize the document content, typically represented in the table of contents or key to the document. From the organizational structure of the document, coverage of the document in terms of life-cycle phases and physical environmental conditions can be derived, since these are most often the means of organizing data within the documents themselves. In all cases, the contents of the documents were mapped onto the standard industry conventions derived from the literature (typical building life-cycle phases, typical stakeholders involved in capital projects, typical physical environmental conditions), based on the content identified by authors as important enough to merit serving as organizational structure or navigation device.

After each document had been characterized in terms of the five parameters, the attributes of each of the documents were mapped in table form to permit comparison of coverage and gaps. The tables were then used as a basis for drawing conclusions about opportunities for improvement based on areas covered or omitted. The findings of the analysis, along with a description of the process used, were prepared in the form of a review paper and submitted to representatives of the agencies that authored each of the guidance documents analyzed. Responses were received from five of the nine author representatives. This review process was used to identify any missed attributes during the analysis and thereby validate the findings of the work.

Guidelines Analysis Data and Results

The nine guidance documents were reviewed to assess their content in terms of their stated goals for use, overall organizational structure, the stakeholders specified as the target audience for the guidance document, the building life-cycle phases addressed by the document's content, and the physical environmental conditions addressed. The following subsections explore each of these parameters in more detail and describe the mappings of the guidance documents across each parameter resulting from the analysis.

Goals

The first step in characterizing the guidance documents was to identify any explicitly mentioned goals for the use of the document. Table 2 shows 11 distinct goals that were identified when reviewing the authors' stated purpose for each document. Similar goals were summarized into a single goal for the purpose of this table. For example, documents intended to provide information, instruct, or familiarize stakeholders have an ''X'' beside the category ''inform stakeholder.''

Organizational Structure

Although the goals of the guidance documents are similar, the documents exhibited a wide variety of 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)

Table 3. Approaches to Organizing Guidance Documents

Headings/Subheading Terms	PSD	CHPS	ID	SPS	TJCoG	LEED	PA	NYC	MN
(a) Building Life-Cycle Phases/Other Processes									
Planning/predesign	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, demolitions, or disposal									X
Commissioning	X	X			X	X		X	
Other processes	X	X	X		X		X	X	X
(b) 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	
(d) 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 subheadings in all of the documents, an ''X'' is included for all since the document is a design guide.

[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 three or more of the documents appear in Table 3.

- 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 subcategories) listed above (see Table 3). An ''X'' was assigned if these categories are included in either the first or second heading level. Not all of the specific design strategies were included in this table, even if these were included in the subheadings. Only those considered part of the organizational structure of the documents for the purposes of this paper were included in Table 3. While most of the documents include background information, benefits of high performance buildings, case studies, 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.

Stakeholders

The next task was to identify intended readers or stakeholders—i.e., the target audience—of each guidance document. This information was obtained by reviewing the introductory sections of each document to identify intended users. Tables 4 and 5 show the target audiences of each guidance document reviewed, mapped onto a list of typical project stakeholders identified in the construction and project management literature (Pearce 1999). Each stakeholder identified as a target audience of a guide is indicated by an ''X'' in the corresponding table cell. 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

Table 4. Intended Readers of Guidance Documents

Direct stakeholders as intended readers[a]	PSD	CHPS	ID	SPS	TJCoG[c]	LEED	PA	NYC	MN[c]
(a) Primarily Preconstruction									
Owner	X	X	X		x	x	x	X	X
Land developers					x	x	x	x	x
Planners		X					x		
Clients									
Developers							X		
Design team[b]	X	X	X	X	X	X	X	X	X
Construction team		x		X	X	x	X	X	x
Financiers								X	
Project managers	X	X			x	x	x	x	x
(b) Primarily Postconstruction									
Users/tenants		X					x	X	X
Facilities managers		X		X			x		
Operators	x	X		X					X
Utilities	x								
Surrounding communities		X					x	X	
Demolition contractor									
Disposal agents								X	
Salvage agents									
(c) Other									
Indirect stakeholders	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. The design team typically includes architects, engineers, specialty consultants, and other design personnel.

[c]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 on which intended readers correspond to each life-cycle phase.

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 involved in the construction...,'' a capital ''X'' is placed beside ''Construction team.'' If a document mentions that an integrated project team may include facilities managers, a small ''x'' is placed by ''Facilities managers.''

Table 5. Additional Intended Readers

Guide	Additional intended readers
PSD	Procurement (contracting) personnel, commissioning agents, and educators
CHPS	''Superintendents, parents, teachers, school board members, administrators, and those persons in the school district that are responsible for facilities''
SPS	Contractors
PA	Decision makers (in general). Other stakeholders who may be included in the project team who are not included in the table above are consultants (design team), contractor and subcontractors (construction), and suppliers and government agencies (indirect stakeholders)
NYC	Regulatory and other agencies, trade associations, commissioning agents, cost estimators, public clientele, city taxpayers, and other municipalities and interested real estate professionals are stakeholders not specifically included in Table 4.
LEED	Materials manufacturers, contractors

Building Life-Cycle Phases

For the building life-cycle phase parameter, each document was reviewed to identify which phases of the building life cycle are addressed. For the purpose of this study, the building life cycle was divided into four discrete phases, each of which includes subphases, described as follows.

Predesign/Planning

This phase of the building life cycle includes every step that occurs prior to when the architect begins putting ideas on paper. During this phase, someone (typically the owner) initiates a new construction or renovation project and strategic planning occurs. In this research, the selection of a project team was 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

Table 6. Building Life-Cycle Phases Addressed in Guidance Documents

Life-cycle phase[a]	PSD	ID	CHPS	SPS	TJCoG	LEED	PA	NYC	MN
Planning/predesign									
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 and 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).

optimization. The construction documents and specifications are written for the construction team to implement.

Construction

Before construction can begin, construction service providers must be selected through a process of bids and/or 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.

Table 6 shows the mapping of guidance document contents onto building life-cycle phases. 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'' was used. First, an ''X'' was 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'' was placed in the ''construction documents and specs'' box if there were recommendations to ''specify'' certain types of technologies or practices. An ''X'' was placed in the O/M management box if a recommended strategy was ''Create a maintenance plan... .'' Second, if a heading or subheading (e.g., construction administration) addresses the building life-cycle phase, an ''X'' was placed in the appropriate box. Third, an ''X'' was used if the document contained a discussion about considerations that must be taken into account during a particular life-cycle phase. For example, if there was a discussion about the importance of bringing together all project stakeholders early in the planning phase, an ''X'' was placed in the ''strategic planning'' box. Finally, if a guidance document specifically included action items to be taken during particular phases of the building life cycle, ''Xs'' would be placed in the corresponding cells. 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.

Physical Environmental Conditions

In the final part of the analysis, each guidance document was reviewed to identify whether or not it addresses 15 physical variables, each having been shown in the literature to have some impact on human performance factors, specifically focusing on student learning or behavior (Bosch 2002). Table 7 shows which documents addressed each of seven physical environmental conditions: electric lighting, daylighting, interior finishes, acoustics, temperature, relative humidity, and indoor air quality. An ''X'' is included for each document if a review of that document identified any content at all that referred to the corresponding physical environmental condition.

Conclusions and Recommendations

Given the potential benefits of high performance building practices, there is a real need to provide effective information sources to support the delivery of high performance building projects. The information sources reviewed in this analysis show opportunities for improvement in terms of their organization and coverage. The

Table 7. Physical Environmental Conditions Addressed by Guidance Documents

Physical variables	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 and 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 and security		X							

[a]Building age and condition are not specifically addressed by the guidance documents. The guidance documents can apply to facilities of any age. The guides 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.

[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 influencing indoor air quality and is addressed by several guidance documents from this perspective.

following subsections present conclusions drawn from each of the five sections of the analysis, along with overall conclusions derived from the study as a whole and recommendations for improving future guidance documents to better address the needs of facilities managers.

Goals

The first step in characterizing the guidance documents was to identify any explicitly mentioned goals for the use of the document. Each of the guidance documents reviewed have two similar overarching 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. The review showed that four of the documents include performance criteria and a rating system for certifying buildings as high performance. The PSD and NYC guidelines, although they do not include rating systems, encourage the consideration of other green building tools such as LEED. One surprising observation is that although the goals of the guidance documents are varied, they are being used in similar ways to varying degrees as part of the facility delivery process in their respective contexts. The LEED Green Building Rating System, for instance, is presently being applied to more than 430 registered projects around the country, and 22 buildings have already been certified (at the time of this writing) under Versions 1.0 and 2.0 of this rating system (USGBC 2002).

Organizational Structure

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 document specifies action items for each building life-cycle phase with each recommended strategy, so that stakeholders involved with those phases can address these issues.

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 nondesign 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,'' 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.

While a review of Table 3 shows that many of the guidance documents contain references to most of the different topics under the four different organizing structures (building life-cycle phases, building systems, topics, and physical environmental conditions), many documents are inconsistent in how information is organized within a hierarchical structure. This lack of consistency may make finding relevant information difficult, as would browsing from one section to another for complementary ideas. Cross-indexing information in future editions of these guides in matrix form may alleviate some of these navigational issues.

Stakeholders

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 and maintenance checklist contains information for such facility maintenance personnel 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. No sections specifically address facilities managers except as part of an integrated design team.

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 occupants, facilities 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. Finally, additional content should be developed that specifically pertains to facilities managers and introduces opportunities for them to incorporate sustainability within the scope of their specific job functions.

Building Life-Cycle Phases

The next part of the analysis identified life-cycle phases addressed within each guidance document. Given the cumulative and ongoing impacts of built facilities over their life cycle, it was expected that content would be present for each of the main life-cycle phases, and in fact the review indicated that this was the case. Each guidance document addresses each of the four major building life-cycle phases (planning and predesign, design, construction, and operation/maintenance) to some degree, with the exception of PSD and CHPS, which do not address operation and maintenance. What is not evident from Table 6 but becomes clear when reviewing the documents is that the vast majority of recommended strategies are portrayed as being best addressed in the design phase. There are fewer recommendations for the construction and operation and maintenance phases. 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 guides provide the most information for the operation and 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. In future versions of the documents, additional information about later life-cycle phases would help increase the relevance and utility of these guidelines for building stakeholders whose primary involvement is in the later phases of the life cycle.

Physical Environmental Conditions

A review of the guidance documents indicates that 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 vs. closed classrooms, and safety and security receive little or no attention in the high performance guidelines.

While the scope of this study focused specifically on the kinds of physical environmental conditions identified in the literature on school facilities, many of these factors have also been shown to be relevant in other kinds of facilities such as offices, processing facilities, and residences (e.g., Romm and Browning 1994). A critical opportunity exists to connect the kinds of research presently being undertaken in building performance and postoccupancy evaluation with the kinds of information needed to provide high performance facilities. The guidance documents reviewed in this study do not explicitly or systematically take advantage of this source of knowledge.

General Conclusions

Several general conclusions can be drawn from the analysis completed in this research. First, 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 built 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. Despite these important roles played by the documents, the approach to organizing information is quite different for each document. The degree to which this affects the effectiveness of different documents in achieving the goals for which they were developed is unknown. However, all four of the documents that include a rating system (LEED, CHPS, TJCoG, MN) have five categories in common—including site, energy, water, materials, and indoor environment. This may represent an emerging common information structure that will become more widely accepted in the United States and may eventually serve as a default structure for information on sustainable building.

Second, by virtue of identifying a broad variety of recommendations to improve both the process and product of capital project development, the documents appear to add value to stakeholders seeking to improve facility sustainability. They include numerous recommendations for improving the facility delivery process and specific strategies for improving the sustainability of buildings.

PROOF COPY [CF/2002/022041] 001301QCF

Third, the stakeholders intended to use the documents range from owners, designers, contractors, and maintenance staff to government representatives, occupants, and members of the local community; but designers and owners are most likely to benefit from using the design guides since there is often information lacking for other types of stakeholders. There are very few (if any) strategies to be addressed by other stakeholders, particularly facilities managers, government representatives, community members, demolition contractors, disposal agents, salvage agents, utility providers, and financiers. There is room for improvement in identifying measures appropriate throughout the life cycle that must be employed to sustain the performance of sustainable buildings.

Fourth, while sustainability guidance documents 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. In fact, many of the guidance documents examined fail to explicitly consider factors (such as installation of monitoring and control systems, education of operators, commissioning, and proactive maintenance) that are necessary to ensure the long-term performance of a facility, although several of the documents reviewed do address postoccupancy evaluations and continuous commissioning. Without requiring appropriate measures, the performance of these facilities may diminish. While there are many protocols for diagnosing buildings and for conducting postoccupancy evaluations, there is no simple, standard approach for ensuring that high performance buildings are actually high performing further down the road. Facilities managers play a crucial role in ensuring that buildings deemed to be sustainable continue to perform as intended during the operation and maintenance phase of the building life cycle. This study suggests a need to modify or extend the guidance documents or develop additional information (using appropriate language and depth) to better address the needs of facilities managers. The resulting tools, targeted specifically to facilities managers, will better equip them to contribute to the sustainable design process so that the associated benefits are realized throughout the life of their facilities. 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 built facilities. This study has shown that there are opportunities for developing additional types of information and tools to ensure that facilities are efficient, economical, and healthy with minimal or no adverse impacts on the natural environment.

Lessons Learned and Areas for Future Research

As a point of departure for improving the effectiveness of guidance documents for built environment sustainability, this study establishes a foundation for significant future research as well as development of practical improvements to existing guidance documents. First, significant opportunities exist to improve the balance and coverage of guidance documents to better address sustainability improvement opportunities across the entire scope of the project. Specifically, better information needs to be provided on how to maintain the sustainability of a facility postconstruction, and specific guidelines should be developed to address stakeholders involved in this phase of the life cycle, including facilities managers, occupants, operators, maintainers, and the surrounding community. This information should be developed and tested to ensure its appropriateness in terms of language, depth, content, and structure for the specific audiences being targeted.

Although it was outside the scope of this study, we have noted that there is a need to empirically evaluate the effectiveness of these guidance documents. As indicated by the sample of documents examined here as well as documents reviewed in other studies (e.g., Pearce and Vanegas 2002), 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 keywords 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. The influence of the way that we organize information and its impacts on the ability of the target audience to comprehend and apply this information has not been studied in the built environment. 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.

Evaluation of the effectiveness of information must focus on both the guidance documents as tools for diffusing sustainability to capital projects, as well as the context in which the documents are used. For instance, how does the way a document is structured affect how well its audience comprehends and applies its guidance? Do the checklist-like structures of many of the guidelines examined here encourage piecemeal application of sustainability strategies, to the detriment of total project cost and performance? What is the best balance between the level of detail in guidance documents and the time constraints of their users? How well do guidance documents work in different project delivery configurations? Does the use of guidance documents by facility stakeholders actually result in more sustainable facilities in the long term? All of these questions remain to be answered in future empirical studies.

Finally, the guidance documents reviewed in this work are but a sample from a rapidly growing body of knowledge in the domain of built environment sustainability. Given the growth of electronic media such as the Internet and the World Wide Web, and the increasing power of information storage and retrieval mechanisms, how will future project stakeholders most effectively access the information needed to make decisions on project sustainability? This study reviewed documents that, while available in electronic form in most cases, still are primarily used in (or as if they were in) print form. The possibilities afforded by new media in representing sustainability knowledge only underscore the importance of understanding the relationships between audience, process, delivered product, and sustainability guidance.

Acknowledgments

The writers would like to thank the Sustainable Facilities and Infrastructure Branch at Georgia Tech Research Institute, the Georgia Tech Foundation, and the Building Technologies Program of Georgia Tech's College of Architecture for supporting this study. Thanks especially to Craig Zimring and Fried Augenbroe of the College of Architecture for reviewing earlier versions of this paper, and to representatives of the organizations who developed the guidelines reviewed here for their editorial comments and review.

References

Arnoff, S., and Kaplan, A. (1995). *Total workplace performance*, WDL Publications, Ottawa, Canada.

Becker, F., and Steele, F. (1995). *Workplace by design: Mapping the high-performance workscape*, Josey-Bass, San Francisco.

Bosch, S. J. (2002). ''Characterization of guidance documents for creating high performance schools.'' PhD Qualifying Paper, Building Technologies Program, College of Architecture, Georgia Institute of Technology, Atlanta.

City of New York. (1999). *High performance building guidelines*, Dept. of Design and Construction, New York.

Collaborative for High Performance Schools. (2001). *Best practices manual: Collaborative for high performance schools*, Eley Associates, San Francisco.

Green, G. H. (1974). ''The effect of indoor relative humidity on absenteeism and colds in schools.'' *ASHRAE Transactions*, American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc., Montreal.

Heschong Mahone Group. (1999). *Daylighting in schools: An investigation into the relationship between daylighting and human performance*, The Pacific Gas and Electric Company on behalf of the California Board for Energy Efficiency Third Party Program. Fair Oaks, Calif.

Innovative Design. (2001). *Sustainable Schools Guidelines*, Innovative Design, Inc., Raleigh, N.C.

Jones-Crabtree, A. J., Pearce, A. R., and Chen, V. C. P. (1998). ''Implementing sustainability knowledge into the built environment: An assessment of current approaches.'' *1998 IERC Conference Proc.*.

Kobet, R., Powers, W., Lee, S., Mondor, C., and Mondor, M. (1999). *Commonwealth of Pennsylvania guidelines for creating high performance green buildings*, Pennsylvania Department of Environmental Protection, Philadelphia.

Lewis, L., Snow, K., Farris, E., Smerdon, B., Cronen, S., and Kaplan, J. (2000). ''Condition of America's public school facilities: 1999.'' National Center for Education Statistics, Washington, D.C.

Menzies, D. J., Pasztor, J., Nunes, F., Leduc, J., and Chan, C. H. (1997). ''Effect of a new ventilation system on health and well-being of office workers.'' *Arch. Environ. Health*, 52(5), 360–367.

Pearce, A. R. (1999). ''Sustainability and the built environment: A metric and process for prioritizing improvement opportunities.'' PhD dissertation, School of Civil and Environmental Engineering, Georgia Institute of Technology, Atlanta.

Pearce, A. R., and Vanegas, J. A. (2002). ''A parametric review of the built environment sustainability literature.'' *International Journal of Environmental Technology and Management*, Special Issue on Sustainability and the Built Environment, in press.

Romm, J. J., and Browning, W. D. (1994). *Greening the building and the bottom line: Increasing productivity through energy-efficient design*, Rocky Mountain Institute, Snowmass, Colo.

Triangle J Council of Governments. (2001). *High performance guidelines: Triangle region public facilities*, Triangle J Council of Governments, Research Triangle Park, N.C.

University of Minnesota. (2000). *Minnesota sustainable design guide*, University of Minnesota, College of Architecture and Landscape Architecture, Twin Cities, Minn.

U. S. Green Building Council (USGBC). (2001). *LEED reference guide*, Version 2.0, Green Building Council, Washington, D.C.

Unger, D., Forrest, K. A., Franzen, B., and Spearnak, M. (2000). *Poudre School District sustainable design guidelines*, Poudre School District, Facility Services & Planning, Design and Construction Services, Poudre County, Colo.

PROOF COPY [CF/2002/022041] 001301QCF