Managing the Cost of Green Buildings

K-12 Public Schools
Research Laboratories
Public Libraries
Multi-family Affordable Housing

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State of California
STATE AND CONSUMER SERVICES AGENCY

Alameda County Waste Management Authority
Alameda County Source Reduction and Recycling Board
www.stopwaste.org

Table of Contents

SUMMARY

Although sustainable building may mean different things to different people, generally speaking, sustainable buildings use resources like energy, water, materials, and land much more efficiently than typical buildings. They are also designed and operated to create healthier and more productive work, learning, and living environments, through the use of natural light and improved indoor environmental quality. From a fiscal perspective, sustainable buildings are cost-effective, saving taxpayers money by reducing operations and maintenance costs.

There are three green building performance standards, the Leadership in Energy and Environmental Design (LEED) Green Building Rating System™,[1] the Collaborative for High Performance Schools (CHPS) design criteria,[2] and the Laboratories for the 21st Century Environmental Performance Criteria (Labs21 EPC),[3] each with national application, which currently set the standard for California's green building efforts.

With the release of the LEED™ Green Building Rating System for New Construction and Major Renovations, the U.S. Green Building Council helped create a common definition and standard for green design and construction. Because of the usefulness of LEED, it has been widely applied in varying forms to building types other than the offices originally targeted—everything from small retail stores and housing to airports. Although parallel systems have been developed to better serve special building types such as the CHPS program and Labs21 EPC, LEED, more so than these other rating systems, has been rapidly adopted both at the local government level as well as by industry. However, there is currently little published information available on how to economically build green on these non-office projects. This report begins to address that issue by providing general cost-saving strategies for green building, and by exploring the cost issues associated with four specific building types in the context of the green building rating systems most commonly used for that sector:

K-12 Schools	LEED and CHPS
Laboratories	LEED and Labs21 EPC
Libraries	LEED
Multi-Family Affordable Housing	LEED and guidelines from: The Alameda County Waste Management Authority[4] Global Green[5]

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[1] LEED™ is a rating system developed by the U.S. Green Building Council for rewarding good environmental practice in building construction. It is useful for comparing the relative "greenness" of projects. General information on LEED is available at www.usgbc.org. Training courses are also provided by the USGBC.

[2] The Collaborative for High Performance Schools. *Best Practices Manual, 2002 Edition. Volume III: Criteria*, 2002. Available at: www.chps.net.

[3] Labs for the 21st Century. *Environmental Performance Criteria*, Version 2.0, October 2002. Available at: http://labs21.lbl.gov/epc.html. Labs21 is a joint project of the EPA and DOE and is described at www.epa.gov/labs21century. Technical information is available from LBNL at http://labs21.lbl.gov.

[4] Alameda County Waste Management Authority. *Multifamily Green Building Guidelines*, 2003. Currently in draft form, available from: Ann Ludwig, Program Manager, aludwig@stopwaste.org.

[5] Global Green USA. *A Blueprint for Greening Affordable Housing: Developer Guidelines for Resource Efficiency and Sustainable Communities*, Summer 1999. Available for download at: www.globalgreen.org.

City of Santa Monica[6]

The emphasis for this study is on new construction and research for this report was conducted for projects primarily located in California, although most of the strategies presented also apply to major renovations and to projects across the U.S. This is not a technical guide; however, lists of resources are provided at the end of each section.

For the purpose of this report, green building is defined as a comprehensive approach to design and construction that addresses the areas outlined by LEED: land use, transportation, landscaping, water efficiency, energy efficiency, atmospheric emissions, materials and resources, waste and the health, comfort, and productivity of building occupants.

Green building practitioners widely agree that there are opportunities to lessen the economic impact of green building by following the strategies described in this report, including:

- Write RFPs and contracts that clearly describe green building requirements, thereby saving time and as much as half the costs associated with implementing LEED. Set a preliminary LEED goal in the RFP and finalize the goal by 50% design development.
- Invest an additional 3% of total project costs during design to yield 10% savings in costs of construction through design simplifications and reduced change orders.
- Set up a cross-disciplinary design team to encourage creative solutions.
- Involve the contractor early in the design process.
- Hire the mechanical electrical and plumbing firm (MEP) at the beginning of design and empower them to fully participate in the entire design process, resulting in savings equal to at least 10% of the MEP construction costs.
- Recognize that green is good practice—and as such should not be considered separate from standard construction. Projects that keep budgets separate (base vs. green), or put most green measures as alternates in specifications, typically end up costing more.
- Spend money on a good energy model and use it to explore first cost and operating-cost savings strategies.
- Standardize the layout of similar spaces.
- Use daylighting and do not ignore the value of a well-insulated building envelope.
- Recognize that current LEED projects cost less than expected. Most Certified and Silver projects are built with little to no additional cost.
- Identify utility, state, and other funding sources to help offset investments in energy efficiency, water efficiency and renewables.

[6] Santa Monica Green Building Program. *Green Building Design and Construction Guidelines*, 1997. Available at: http://greenbuildings.santa-monica.org.

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General Strategies

BACKGROUND

Despite the growing body of research detailing the environmental and human health benefits of sustainable construction, the decision to design and construct a green building is still largely based on initial cost. Although cost data is increasingly available, the "premium" for greening is still hard to pin down and is therefore often presented as a large range. The popularly cited range for building to the LEED™ Certified or Silver rating is 1 to 5% of the total base project cost.[7] More recent projects are generally incurring costs on the lower side of that range,[8] but there are examples of projects that have come in under budget and others that have cost upwards of 10% more. Therefore, the more relevant questions seem to be:

- What are the factors that make some projects cost less than others?
- Why do some projects cost so much more, and how could costs be better managed in the future?

The premise of this paper is that it is more useful to determine how to keep a particular project at the low end of the cost range than to debate whether the range is accurate.

This paper describes how to control the costs of green building projects by summarizing the research done on that topic for the Alameda County Waste Management Authority (ACWMA), the California State and Consumer Services Agency (SCSA), California's Sustainable Building Task Force, and the California Department of General Services (DGS).

Two Executive Orders direct California's efforts to integrate sustainable building practices into the state government capital outlay process:

- Executive Order D-16-00 establishes the Governor's sustainable building goals; and
- Executive Order D-46-01 provides guidance on the process the state should use to locate and lease space.

Fundamental to implementing these Executive Orders is the overarching issue of defining what sustainable goals are "cost effective." This paper addresses the issue of how to approach a green building project from a cost perspective.

OBSERVED COSTS

There is little published data about the actual cost of green buildings and particularly about actual cost premiums for LEED-rated green buildings. The USGBC, the developer and administrator of the LEED certification process, does not require that cost information be included with

[7] The cost of assembling the LEED submittal is included in these percentages.

[8] Greg Kats, Capital E. *The Costs and Financial Benefits of Green Buildings* points to a 0-2% range for LEED projects between Certified and Gold.

submissions for LEED certification. However, from KEMA Xenergy's surveys of the industry, the capital costs of design and construction vary significantly, depending on the specific project goals. While there are some green building measures that may be achieved as a matter of course with no change in cost (e.g., recycled content structural steel), some green building features involve a change in practice that effectively moves costs from one budget to another, usually shifting costs from operation and tenant budgets to design and construction.

The challenge is that while lifecycle analysis may fully justify additional investment up front in the project design, there may be no source of supplementary funds available at the time of construction. This section surveys completed projects to determine the magnitude of the green premium required for design and construction.

What does LEED cost?

The cost to achieve LEED certification can depend upon a variety of factors and assumptions, including:

- Type and size of project;
- Timing of introduction of LEED as a design goal or requirement;
- Level of LEED certification desired;
- Composition and structure of the design and construction teams;
- Experience and knowledge of designers and contractors or willingness to learn;
- Process used to select LEED credits;
- Clarity of the project implementation documents;
- Base case budgeting assumptions.

In addition, the costs will vary, depending upon whether only capital costs are considered or if costs are calculated over the life of the building. Finally, successful enforcement of a policy based on the adoption of LEED will depend on the level of up-front financial commitment to internal program support, policy implementation, and external market transformation.

Each of these factors will contribute to the overall cost of implementing LEED, and because each factor can vary significantly on a project-by-project basis, the cost of each LEED project is different. However, as more and more projects go through the LEED rating process, a general picture of costs is beginning to emerge.

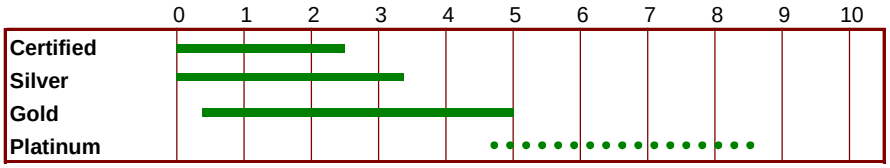
Many building industry professionals maintain that if the stakeholder is committed at the project conception *and* the design and construction team has moderate sustainable design and construction experience, a LEED Certified building can be achieved on a conventional building budget. Projects throughout North America have already proven this. However, it would be shortsighted to simply assume that all building projects in all marketplaces can currently achieve a LEED Certified rating on a conventional budget.

Across the U.S., green building consultants in all building sectors have been revising their expected cost of achieving a LEED Certified rating downward in recent months, based on experience and on research, such as the companion report on The Costs and Financial Benefits of Green Building.[9] Previously, consultants would identify a typical range of 2 to 5% additional cost for Certified projects and upwards of 5 to 10% or more for higher LEED ratings (Silver, Gold, or

[9] Kats, G., et al., "The Costs and Financial Benefits of Green Building," California Sustainable Building Task Force, October 2003.

Platinum). The range is a percentage of total construction costs and includes design- and construction-related fees. Projects that have required no net additional cost include the Capital East End in Sacramento, California (Gold),[10] the Brengel Tech Center in Milwaukee, Wisconsin (Certified),[11] the EPA Regional Office in Kansas City, Kansas (Silver),[12] and the Portland Building in Portland, Oregon (Silver).[13] In contrast, the team designing the West Valley Branch Library in San José decided to pursue a LEED Certified rating late in the design process (at 50% construction documents) and incurred additional project costs of more than 6%.[14] Even so, local consultants that provide cost-estimating and consulting services maintain that a LEED Certified building with a reasonable base budget should be achievable within project budgets or very near to no additional cost as long as the decision is made early in design.[15] Figure 1 shows the range of observed incremental costs for each LEED rating level across all building types.[16] Project managers interviewed for this report confirmed that these ranges coincided well with their projects.

Figure 1. Typical incremental percentage capital cost of meeting LEED[17]



Note that these ranges are considerably lower than previously assumed. The general consensus, based on conversations with green building consultants, until very recently had been that Certified costs from 1 to 3%, Silver 2 to 6%, Gold 5 to 10%, and Platinum 7% and up. Those numbers are now markedly lower.

Although experience with LEED and green building is growing nationwide, few municipalities have gathered concrete information on the cost of greening. Seattle, Washington remains one of the leaders in the green building movement, and was the first municipality to require LEED Silver certification for all municipal facilities over 5,000 square feet. Unlike other cities and counties just developing green building policies and regulations, Seattle has already begun to gather data on policy implementation.

Seattle

The City of Seattle reports that the average incremental cost of meeting LEED Silver across all projects is 1.7%.[18] In addition, data show that the incremental cost of LEED is decreasing over

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[10] Information supplied by the California Department of General Services, August 2003.

[11] Urban Environmental Institute. *Resource Guide for Sustainable Development in an Urban Environment: A Case Study in South Lake Union Seattle, Washington*, October 2002. Available at: www.usgbc.org/resources/research.asp.

[12] C. C. Sullivan. Off the Shelf Ecology, *Building Design & Construction*, May 2001, pp 57-60.

[13] Urban Environmental Institute. Op. Cit.

[14] The Mayor's Budget Message available at www.sjmayor.org/memos/bmessage2001.html appropriates $491,000 for the $7.9 million project to cover LEED certification.

[15] Conversations with Bill Reed of Natural Logic, Tom Paladino of Paladino & Company and internal experience at KEMA-Xenergy.

[16] Bill Reed. Plenary Presentation. EnviroExpo, Boston, April 2003.

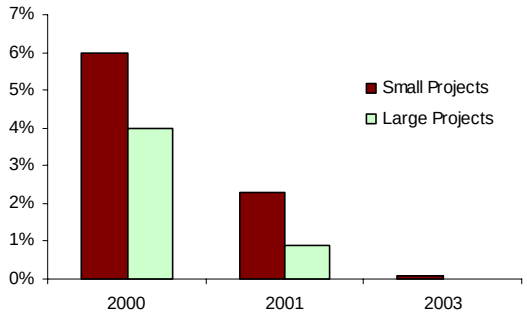
[17] Northern California LEED project cost estimates gathered by KEMA Xenergy. Contact Geof Syphers at 510-891-0446 for more information.

[18] Lucia Athens and Tony Gale. *Developing a Public Portfolio of LEED Projects: The City of Seattle Experience*, Proceedings of the 2002 International Green Building Conference and Expo, Austin, TX, November 2002. Available at: www.usgbc.org/expo2002/schedule/documents/DS509_Athens_P126.pdf.

time: current Silver projects show no incremental cost. Figure 2 shows cost premiums for achieving LEED Silver for both large projects (over $10 million) and small projects (under $10 million) for the period from 2000 through 2003. This trend is one indication of the decreasing costs of green building resulting from the increased experience of project teams.

For projects with budgets less than $5 million, the LEED application process and documentation of each green measure can be a significant proportion of the added costs. Nigel Howard and Rob Watson reported in 2002 that, "While LEED documentation costs can be as low as $10,000 for an experienced team, this appears to be unusual. Most teams are working on their first LEED project and often report costs in the range of $30,000-$60,000."[19] Fortunately, more design teams and consultants are gaining experience and beginning to lower their fees for LEED documentation. Nevertheless, smaller projects have the option of using the LEED system as a design guide without pursuing an official rating because of the relatively high fraction of project costs represented by documentation.

Figure 2. Trend in Incremental Cost for Meeting LEED Silver in Seattle[20]



California

In California, most new state construction projects should achieve the points needed for a LEED Silver rating within standard building design & construction practice.[21] Projects in California achieve some credits and prerequisites by default. Existing building standards and local ordinances fulfill some of the LEED credit requirements related to construction and demolition waste recycling, stormwater management, and energy efficiency. The minimum number of points needed for each rating is shown in Table 1. Note that the number of points recommended for submittal is 2 points higher than the minimum because 1 or 2 points are often denied during document review.[22]

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[19] Nigel Howard and Rob Watson. "Special LEED™ Section: An Update on LEED™ 2.1," *Environmental Design and Construction*, July 12, 2002.

[20] Personal communication with Lucia Athens and Tony Gale.

[21] Total number of points achieved within existing construction delivery depends upon location of building (urban, suburban or rural); retrofits generally achieve fewer points (as standard practice) than new construction projects.

[22] Note that while there are 34 LEED credits (in addition to 7 prerequisites for which points are not granted) there are 69 LEED points as some credits may result in more than one LEED point. Certification is granted based on the number of points achieved for the credits defined within the LEED rating system.

Table 1. Credits for LEED™ 2.1 certification

Rating	Required Minimum Points	Recommended Points for Submittal
Certified	26	28
Silver	33	35
Gold	39	41
Platinum	52	54

Getting to LEED Certified in California

Our review of 38 local public libraries, college dormitories, community centers, fire and police stations, city halls, detention centers, courthouses and offices considering LEED certification found that the default scores ranged from 12 to 28, with higher-end projects (e.g., courthouses, city halls, police stations, and large offices) scoring in the upper half of that range and mid-range projects (e.g., small offices, schools, libraries) scoring in the lower half.

Quite a few credits may be achieved with little to no additional expense, which makes reaching the Certified rating affordable. These include (among others): using low-VOC paints, diverting 50% of all construction and demolition debris out of landfills, exceeding the energy code by 15%, and developing public information displays. Additional strategies for keeping costs close to zero are described in the section titled *Managing Costs*.

While the Fundamental Commissioning LEED prerequisite is considered burdensome for many projects, the California state government recognizes the value of commissioning and is currently working to incorporate in-house commissioning for all new construction projects and major renovations. Commissioning buildings not only results in reduced lifecycle costs by ensuring that buildings are operating as they were designed, but when done correctly, may significantly reduces the number and extent of change orders, thereby reducing the up-front costs of construction as well.[23]

Getting to LEED Silver

Implementing the additional seven credits over the Certified level to reach LEED Silver may frequently be accomplished within project budgets, especially if the Silver goal is set prior to the schematic design phase. Therefore, during project design it is important to consider that several measures yield multiple credits. That is, by designing for one credit, the project meets requirements for other credits as well. For example, selecting materials with low emissions that also have recycled content or are manufactured locally can achieve Materials credits *and* Indoor Environmental Quality credits. Other general measures that yield multiple credits include displacement ventilation, solar photovoltaics, daylighting, and green roofs.

Getting to LEED Gold or Platinum

For Gold- and Platinum-rated buildings, estimating costs becomes more complex and less reliable. There are fewer projects that have achieved this level of LEED, and greater variability

[23] Chad Dorgan, Richard Cox, and Charles Dorgan.. The Value of the Commissioning Process: Costs and Benefits. Farnsworth Group, Madison, WI. Proceedings from the 2002 US Green Building Council Conference and Expo , Austin, TX. November 2002. Available at: www.usgbc.org/expo2002/schedule/documents/DS506_Dorgan_P152.pdf.

among them. All the factors that affect costs on Certified and Silver projects become more important to manage to further minimize impact on costs. Design teams with a goal of Gold or Platinum tend to incorporate significant whole-building solutions, such as equipment downsizing.

Cost of LEED project management for USGBC certification

Assisting, guiding, and coordinating the team's documentation efforts as well as producing, organizing, and compiling the documentation materials can be considered LEED Project Management. The LEED Project Manager (PM) could be the owner, the architect, or a separate consultant. The size or construction cost of a project has less of a bearing on the cost of LEED Project Management, then does the number and nature of credits being pursued. Submittal documentation is gathered throughout all phases, from pre-design through building occupation, and varies by prerequisite and credit.

Current estimates to document, manage, and report project compliance through the USGBC certification process range from approximately $10,000 to $60,000 per project.[24] These estimates will vary on a project-by-project basis and will depend on the complexity of the building type, the green measures targeted, the LEED Rating pursued (how many credits to document), whether or not the project stakeholder is committed at the project conception, and the level of green building experience of the design and construction team.

COST FACTORS

The factors that add cost to green building projects may be grouped in categories relating to local conditions, the project, design, construction and operation.

Local Conditions

The state of California is a good place to build green. State and local laws are already fairly stringent with regard to energy use as well as air and water pollution, and there are more LEED Accredited Professionals in California than anywhere else.[25] In addition, energy efficiency and alternative power production are broadly promoted by the Investor Owned Utilities' *Savings by Design* program[26] and substantial buydown programs for solar photovoltaic systems.[27]

Despite policies that support environmental construction, some state regulations may create obstacles to implementing specific green strategies.

- **Water-free urinals.** The California Plumbing Code is often interpreted to prohibit the use of water-free urinals based on language in Section 406.2, stating "Urinals…which have an unventilated space or wall which is not thoroughly washed at each discharge shall be prohibited," and Section 601.0, stating "…each fixture shall be provided with an adequate supply of potable running water…"

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[24] Nigel Howard and Rob Watson. July 2002. Op. Cit.

[25] USGBC website. See: www.usgbc.org/LEED/Accredited_Pros/professionalaccred.asp

[26] Savings by Design. See: www.savingsbydesign.com.

[27] Photovoltaic buydown programs are offered both by the major utilities in the state, as well as the California Energy Commission. See: www.sustainableschools.dgs.ca.gov/SustainableSchools/financing/energy.html for a full list of energy incentives available in California.

There are four important points to consider before rejecting the use of water-free urinals:

- Not all municipalities have adopted these sections of the plumbing code.
- Even where this code is implemented, exemptions can be granted.
- Water-free urinals are installed in several California state and municipal buildings with generally favorable results.[28]
- Officials responsible for maintaining the Uniform Plumbing Code have recently developed a set of Interim Guide Criteria (IGC) for water-free urinals in recognition of the shortcomings of the current code language.[29]

- **Composting toilets.** Local jurisdictions generally place difficult restrictions on the use of composting toilets.[30] However, there is a strong interest in reducing the amount of potable water used for sewage conveyance and exemptions may be made for specific cases.
- **Greywater collection.** Local regulations place restrictions on greywater collection and use. Despite these restrictions, greywater is increasingly utilized for irrigation and even, in some cases, for toilet flushing and other nonpotable uses.
- **Power generation.** Solar panels are generally encouraged in regulations; however, local planning review boards can sometimes make it difficult to locate panels on sloped roofs in view of public roads. That issue must be addressed early on by building political support for the idea of a system in full view before submitting for plan review. Local building codes place limitations on the heights of structures, including windmills, and zoning restrictions limit the placement of windmills. Nevertheless, small wind power generators are gaining support as the technology continues to get quieter and more compact.
- **Light pollution reduction.** Local minimum illumination requirements restrict opportunities to reduce lighting levels, but mostly apply along dense urban corridors where the concern over light pollution is less significant. Across California, these requirements are increasingly flexible due to an increased focus on energy efficiency in response to the recent energy crisis that followed the abuses of deregulation in the state.

Project

The cost factors associated with a green project cover an array of issues from decision maker buy-in to contracting and project management. Strategies to manage these cost factors are presented in the section titled *Managing Costs*. Table 2 summarizes the project-related cost factors. Project managers in capital projects and other owner representatives are primarily responsible for addressing these factors.

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[28] Provide list of locations where urinals have been installed.

[29] International Association of Plumbing and Mechanical Officials. *Interim Guide Criteria* IGC 161-2000. Available at: www.iapmo.org/iapmo/standards.html.

[30] For example, Mendocino County allows composting toilets only on rural sites at least 10 acres in size, according to the Local Government Internet Resource, See: www.pacificsites.com/~mendocty/depts/eh/minstan.htm.

Table 2. Project Cost Factors *Project Managers*

Cost Factors	Mitigation Strategies
Timing	Introduce the green goal as early as possible, preferably before the Architecture and Engineering (A/E) contract is signed.
RFPs and contracts	Include specific green requirements.
Clarity of commitment	Work with top decision makers to get them on board.
Strength of project managers	Involve experienced and confident project managers familiar with the special requirements of environmental design who are good at coordinating teams.
Value engineering process	Ensure that the value engineering process acknowledges system interdependence and allows adequate time to analyze costs and benefits of green aspects of the project.

Design

Green buildings can incur higher soft costs because of additional design analysis, computer modeling, commissioning, product research, and lifecycle cost analysis for alternative materials or building systems. These higher up-front costs can be recovered through:

- Reduced maintenance, churn, and renovation costs;
- Reduced utilities (electricity, gas, water);
- Improved health and productivity of occupants;
- Lower debt service;
- Decreased liability;
- Longer life of building materials;
- More desirable workplace, worker retention, tenant occupancy.

In general, design-related cost factors have been better addressed than project management factors in industry guides and journals. Table 3 summarizes the design-related cost factors. Architects, engineers, and users are primarily responsible for addressing these factors.

Table 3. Design Cost Factors *Architects, Engineers, Users*

Cost Factors	Mitigation Strategies
Design load	Work with the design team to create a realistic maximum anticipated load to avoid oversizing power, ventilation, and cooling systems.
Degree of standardization	Consider standardizing equipment locations and types to save on construction costs by keeping the design simple to build.
Flexibility of building users	Determine early on if the users support potential innovative changes that may affect the way they use the building.
Plan for growth	Carefully consider the costs and benefits of planning for expansion capability. Expansion can be a very useful and environmentally sound way to meet future

	needs without having to construct an entire new building; but it also can mean building expensive features now that may never be used.
Materials and systems	Consider opportunities to transfer funds from operation and maintenance budgets into capital construction funds to help pay for more durable and efficient products, which often incur additional up-front costs.

Construction

The greatest financial benefits of green building accrue in construction. Due to additional time spent on the integrated design and commissioning processes, there are usually many fewer change orders resulting in significant cost savings. Other areas where there are cost impacts are described in Table 4.

Table 4. Construction Cost Factors *Commissioning Agent, Contractor*

Cost Factors	Mitigation Strategies
Uncommon Trades & Materials	Specifications for new and unusual construction elements should include confirmed contact information for subs and suppliers.
Commissioning	LEED commissioning should continue through construction and turnover to ensure compliance with the construction documents. Refer to the LEED 2.1 Reference Guide and look for upcoming publications from the USGBC that better describe the requirements for LEED documentation.[31]
Change orders	Change orders are generally less common on green building jobs due to the high level of scrutiny that takes place during charrettes and while creating the commissioning plan. Ensure this by hiring the commissioning agent early and including a functional review charrette late in design.
Documentation	The LEED documentation effort continues through construction, and the activities associated with gathering detailed invoices, waste tags, and the like take time. It is helpful to include activities that support documentation in each subcontractor's agreement (e.g., payment for waste hauling will be upon receipt of recycling facility and dump tags; all invoices must provide detail on the separate cost of materials).

Two requirements of LEED are particularly foreign to contractors. The first is that the cost of materials must be documented separate from labor, and the second is that dump tags must be saved to document the percentage of recycled construction and demolition debris. LEED requires that the calculations for the Recycled Content Materials, Rapidly Renewable Materials and Regional Materials credits be based on the total cost of all project materials. That calculation can only be completed if the subcontractors supply invoices with the costs for labor and materials

[31] A USGBC guide to LEED commissioning is anticipated in late 2003 or early 2004.

listed separately. Because this is so different from standard practice, be sure to include the requirement for detailing materials on invoices into the initial bid requests.

Operation

In theory, the startup and operation of a green building should be smoother than that for a standard building because of the thorough commissioning involved. The reality, of course, depends on how well the process was managed and the complexity of the building. It is also possible, depending on building materials and construction IAQ practices, that new inhabitants will experience fewer building-related health problems than they would in a conventionally constructed facility. Throughout the life of the building, there are likely to be some additional costs from maintenance of nonstandard systems and the continuous commissioning process, but these costs should be more than recovered through reduced maintenance on standard equipment as well as energy, water, and material savings from the more efficient systems. Table 5 describes the major operation cost factors.

Table 5. Operation Cost Factors *Users, Maintenance, Janitors*

Cost Factors	Mitigation Strategies
Maintenance	Review routine maintenance practices regularly to avoid long-term problems related to moisture, wear, vandalism, etc. New systems installed to support green building objectives may require maintenance that typical building systems would not (e.g., rainwater collection). Be sure to follow the maintenance plan for these special building elements and hold regular training sessions for new and existing staff.
Continuous commissioning	Energy use and equipment performance can change over time. Continuous commissioning is an important part of on-going cost control.
Cleaning	Regular cleaning can help reduce wear on floors and other surfaces. It is important to review the cleaning techniques and products to be sure they do not cause health problems or inadvertently wear out surfaces faster (as may be the case with abrasives).
Delay in repairs	Users should know how to contact maintenance and janitorial staff and be encouraged to report problems promptly.

BARRIERS TO CONTROLLING COSTS

There are real limitations to how much time and budget are available to optimize design—even when investing additional resources up front has the potential to reduce costs overall. In addition to time and budget constraints, there are a variety of barriers worth examining.

The top five barriers to controlling costs are:

1. **Lack of a clear green design goal;**
2. **Mid-stream attempts to incorporate green;**

3. **Decentralized management of the green building process;**
4. **Lack of experience/knowledge with green building; and**
5. **Insufficient time/funding.**

Lack of a clear green design goal

The sooner a clear green design goal can be established, the better—ideally before releasing the initial design RFQ/RFP. In reality, key decision makers may be too uncomfortable to commit to a green goal without information about the associated financial and timing risks. If that is the case, a preliminary goal may be set in the initial contract to allow the owner to revisit the goal at a specified time—generally after the first complete cost estimate, toward the end of schematic design.

Including a clear green design goal (e.g., LEED Silver, following the Labs21 EPC 2.0 guide, or self-certifying through CHPS) in the contract language is an effective way to set expectations early that the design must achieve the green goal within the specified budget. Without that clarity, the green requirements may be considered add-ons rather than an integral aspect of design, and that can breed a perverse incentive for the designer to show how expensive green *could* be.

A related challenge will arise if top decision makers are not fully committed to the green building process. The pressure of time and money often leads decision makers to look for easy opportunities to cut costs, should the project become challenged. The entire team must understand the green design process up front and stand behind it to eliminate unnecessary and excessive design costs.

The consulting market is still learning how to provide green building services, and competition for the few active firms is still light in most markets. As a result, there has been a tendency for consulting fees to be high. For LEED projects, the USGBC plans to address this trend by releasing a reference document detailing the expected costs of documentation/greening fees based on past submittals and the growing design industry's experience with the LEED system.[32]

Mid-stream attempts to incorporate green

In some cases, the decision to pursue green building measures is made midway or later though project design. The result is almost inevitably increased cost due to redesign and associated change orders. Despite the associated cost increases, even projects that move to pursue LEED certification during late stages will gain from reduced operating costs and other associated environmental and human health benefits.

As an example, the decision to construct the City of San José's West Valley Library using the LEED Certified standard was made just after the 50% construction documents were completed. In an analysis of project costs, KEMA Xenergy found the additional costs associated with the change were a little more than 6%, involving redesign work and additional research to specify a number of different materials. In effect, some aspects of this building were designed twice: once to typical practice and once to the design standards of LEED Certified.

Decentralized management of the green building process

There are a few shared components among all successful green building projects, and chief among them is the green building point person, or sustainability coordinator. Without a single

[32] Communication with Christine Ervin, USGBC.

point of responsibility for ensuring correct application of green building strategies, especially when using specific green building guidelines or rating systems such as LEED, green building efforts may become fractured, time may be wasted, and unpleasant surprises may result.

The green building point person is critically important because he or she is responsible for tracking all the details and making sense of the process.

Table 6. Project Management Cost Factors *The Green Building Point Person*

Qualities	Tasks
Knowledge of green building process Sufficient authority to make rapid project decisions Highly organized	Maintain current green building checklist or scorecard (e.g., LEED, CHPS, Labs 21EPC, etc.) Track assigned tasks relating to green building Ensure project calendar reflects green building activities Collect and assemble green building documentation (where appropriate)

Lack of experience/knowledge with green building

A lack of experience with green rating systems (e.g., LEED, CHPS, Labs 21), green building components, and energy- and water-modeling programs can significantly impact the project budget. For example, the design team may waste time researching inappropriate technologies, or the owner could accept a bid that is two or three times too large for commissioning services. As design teams gain experience, the amount of time required to successfully integrate green into a project will be reduced significantly. It is therefore essential that design teams include a minimum level of green expertise, such as having several key staff who have passed the LEED accreditation exam.

Many design teams now have LEED Accredited Professionals on staff. However, these individuals may not be specifically assigned to the project in question. For a successful LEED project, it is essential that the inclusion of this individual be stipulated in contract documents. In addition, it is often useful to include an outside perspective for brief consultations to help guide the internal staff, and decrease their learning time.

Green consultants may be retained to review the project at the following intervals:

- Initial goal setting;
- Mid-schematic design;
- Mid-design development;
- Early construction documents;
- Just before going out to bid.

Not all green consultants are equally qualified. It is important to check their references to see how well they have provided assistance in the past. For LEED projects, questions should be asked regarding the accuracy of their judgments on predicting how the USGBC would rule on various credits and how realistic their design assistance advice has been.

It is also important to identify good written resources before the project is far along. There are hundreds of websites that have guides to recycled content materials, chemical storage, indoor air

quality, and so on. Few of these sources are consistently reputable, however, and most have serious shortcomings in documentation.

Insufficient time/funding

There is rarely enough time to fully research all the interesting new green materials and technologies, just as there is rarely enough funding in the budget to pay for everything—even for things that pencil out on a lifecycle basis. Therefore, it is useful to work out a process for discovery and decision-making ahead of time. In addition to identifying useful sources of information, it is helpful to explore the different cultures of decision-making that exist for the owner and the design team. Consider how different kinds of decisions will be made. Some types of decisions must be made by the owner, some by the mechanical engineer, some by the architect, based on their particular areas of expertise and responsibilities. However, the collaboration element in green building projects requires that many perspectives be consulted as new ideas are explored and implemented.

Maximizing the value of a construction project often means investing more up front to return significant operational savings over the life of the building. A primary difficulty in financing green projects is therefore not the "green premium," but rather the inability to transfer funds between capital and operating budgets.

Additional Barriers

Other barriers that may be somewhat less urgent to address include inexperience with design charrettes, late involvement of specialty consultants, and lack of awareness of incentives/rebates and code violations (e.g., Uniform Plumbing Code is frequently interpreted to prohibit installation of waterless urinals).

Notably absent from these barriers is any lack of available design professionals familiar with applying green building principles. California is home to more LEED™-accredited professionals than any other state; therefore, project teams are in a good position to access this expertise.

MANAGING COSTS

Despite existing barriers to incorporation of green design, there are many opportunities to manage and minimize these costs. This section presents strategies for increasing the efficiency of project managers and design teams attempting to build green.

Is it the right project?

Consider whether the project is best suited to achieve a green certification, such as LEED or CHPS, or whether it is best to use these rating systems as guidelines without going through the certification process. Not every project can successfully take on the challenges of certification. For example, there are a number of important criteria that should be met for every LEED project, including:

- Support from senior decision makers;
- Introduction of LEED before completing construction documents (preferably *much* earlier);

- For renovations or infrastructure projects, the scope should be significant, covering at least finishes and systems;
- Project can meet all of the LEED prerequisites.

However, even if the project does not meet all of these criteria, it is still possible to use LEED as a design guide and develop the most sustainable design practical.

Start early and set a clear green goal

Set a high, but reasonable green goal early in the process. Over the long term, it is cheaper to make a commitment early in the process and invest money up front during the soft-cost phase instead of attempting to change designs later. Ideally, the decision to go green should be made before soliciting design proposals so that contract language may reflect the green goal. This allows more flexibility in decision-making and increases the opportunity to save money. Including the green goal in the contract language is also an effective way to set expectations early that the design must achieve the green goal within the specified budget. Without that clarity, LEED requirements may be considered an add-on rather than an integral aspect of design, creating a perverse incentive for members of the design team to show how expensive LEED could be.

Not all green building measures add cost, but the ones that save money usually must be made early (e.g., siting, orientation, choice of structural systems). Generally, investing in soft costs (integrated design strategy, energy modeling, clear contract documents, and specifications) allows the project team to avoid hard-cost mistakes (delays, change orders, callbacks).

In setting the goal, it is valuable for consultants to take the time to understand the owner's motivations. For example, one private laboratory in St. Louis had no interest in green measures for their environmental benefits but had a strong interest in daylighting and indoor environmental quality because the company felt that these features would help to attract and retain the best research talent in a competitive market.

Finally, it is important to remember that the size or construction cost of a project has less bearing on the cost of LEED project management than the number and nature of credits pursued. Current estimates to document, manage, and report project compliance range from approximately $10,000 to $60,000.[33] Keep this number toward the lower end by working with an experienced firm and staying current with USGBC efforts to streamline documentation. At the beginning of the design process, provide a binder to each firm that has their submittal requirements spelled out and copies of the letter templates they will eventually need to sign.

Contract for success

Write RFPs and contracts that clearly describe green building requirements (i.e., LEED Silver) thereby saving time and as much as half the costs associated with implementing LEED.[34] RFPs for design services should require bidders to summarize their sustainable building experience and qualifications, and these qualifications should be evaluated as part of the selection process. RFPs for contractors should require bidders to provide specific strategies for jobsite recycling and coordination of unusual construction elements.

If possible, consider using a best-value bidding process that sets a fixed budget and allows bidders to describe what they can include for that price. If such a contract is not possible, LEED

[33] Nigel Howard and Rob Watson. July 2002. Op. Cit.

[34] KEMA Xenergy experience. Contact Geof Syphers for more information at 510-891-0446.

requirements should be included in the initial Request for Qualifications (RFQ) as well as in the design and construction contracts. It is also helpful for the contractor to include a list of LEED credits each sub is responsible for in the subcontracts.

The Capitol Area East End Complex in Sacramento is a good example of how a best-value process can deliver a green building at a reasonable price. Project teams responding to the Request for Proposals (RFP) were required to incorporate specified sustainable features within the fixed project budget, but were also awarded points for incorporating additional green features, so-called "innovation points." Although no additional funding was available, Block 225 (the first of the five buildings to be completed) achieved a LEED Gold rating, and included such innovations as a building integrated photovoltaic system, utilization of reclaimed water from drinking water fountains to supply the outdoor fountain, and an integrated pest management program relying on native plantings and beneficial bugs. The remaining four buildings in the complex went through a similar process and are expected to achieve the Silver level.[35]

Build a good team

The design and construction process for an owner or design team's first green project is often characterized by significant learning-curve costs and occasionally by delays. In addition, the relative newness of green technologies and systems can lead to conservative decision-making from designers, architects, and owners. They may add contingencies and risk factors to green building systems and not fully integrate them into the building, thereby reducing the potential for cost savings and other benefits. Cost estimators also add uncertainty factors for new technologies they are not familiar with, and these can further inflate cost.

The costs of green buildings tend to decline with experience in design and development, as owners and their design teams move beyond their first green building. Specifically, as project teams and design firms become more experienced with green building rating systems and guidelines, specifically the LEED Rating System and certification process, the number of hours necessary to implement, track, and document green building systems and features is reduced. This has been the case in both Portland, Oregon and Seattle, Washington where, after several years of implementation, these costs have declined significantly.[36]

To capitalize on these cost saving opportunities, select a team that has experience with green building, preferably with direct experience implementing the particular rating system or guidelines of choice. At the very least, select firms that have experience with the collaborative process, design charrettes, and green building value engineering. If there is no direct experience with LEED or other guidelines on the project team, hire a consultant as an on-call advisor.

- Select proactive project managers (PMs) who will champion the owner's green interests and actively manage and direct the design team. Passive participation by the PM will hinder your chances for successful implementation of green; PMs need to be willing and empowered to ensure that appropriate green measures are preserved. Effective PMs will be skilled at efficiently managing cross-discipline meetings.
- Select design teams that have sustainable design embedded within the firm's design culture. At the very least, the green design experience of the architect/engineer (A/E) should either reside within the firm or be accommodated by means of a

[35] Information provided by the California Department of General Services, November 2002.

[36] Communication with Lucia Athens, City of Seattle.

consultant with whom the A/E has had extensive sustainable design experience on previous projects.

- Look for a design team that has a history of creative problem solving to achieve efficient and otherwise effective solutions. The A/E team should also be comfortable working through challenges in owner and user charrettes.
- During the application and interview process, require that A/E firms:
  - When using LEED, include at least one LEED Accredited professional on the design team (preferably from the lead A/E firm).
  - Include a résumé of the A/E who will be in charge of the project. Include the person's experience with green building projects, such as whether or not they are a LEED™ Accredited Professional.
  - Explain their expertise with environmentally responsible or sustainable facility design and their specific expertise in applying integrated design concepts and methodologies.
  - Discuss opportunities for integrated design within team disciplines and how to effectively execute within industry standards.
  - Demonstrate experience with completed projects that use less heating, cooling and lighting energy than the energy code allows.
  - Provide a list of client references for green building.
- Include one LEED PM or sustainability coordinator to act as the green building point person to monitor green design and construction and coordinate all green building documentation. This person should be recognized as the person in charge of information management and for LEED projects should be a LEED Accredited professional. It is critical to get this person on board as early as possible, and he or she should remain on the team until the project is completed and the documentation is submitted for review and accepted.
- Hire a strong mechanical, electrical and plumbing firm (MEP) at the beginning of design and empower them to fully participate in the entire design process. Because so much of the operating costs relate to equipment maintenance, renovation, and energy use, hiring a good MEP is always worthwhile. In addition, KEMA Xenergy has found that hiring the MEP early in design typically leads to savings of at least 10% of the mechanical equipment and installation costs.

Educate the team & identify good sources of information

Encourage team members to get further training. Most owners are surprised to learn that LEED Accreditation indicates a minimum level of expertise with the LEED Rating System. The current exam can be passed with only a working knowledge of LEED and almost no application-related experience, so credentials are currently a poor indicator of qualifications. Various LEED practical application courses are now offered, and some seminars now address the implementation side of LEED better than the basic LEED training. It is also possible to hire consultants to provide training tailored to a specific project. Much can also be learned from case studies of similar projects by reviewing lessons learned with other project teams and owners.

Specific information needs on every project include:

- Materials availability, quality, and price, and green attributes such as recycled content, VOC content, and place of final assembly;

- Technical and pricing information on advanced systems like underfloor air distribution, heat recovery, energy management systems, and daylighting strategies;
- LEED credit interpretations (access to past rulings and prediction for current project); and
- LEED process advice.

Set clear expectations for green building project implementation

Throughout the design and construction process, it is crucial to set clear expectations for green building project implementation. The clearer the expectations, the greater the possibility of managing any unnecessary costs that are potentially attributable to green building related efforts. The owner should set clear expectations for the project manager through a vision statement with a specific green building goal or requirement, for example LEED Silver. The A/E PM should clearly relay that goal to the design team through the advertisement, RFP/RFQ, and meetings during the design process. The design team must set clear expectations for the contractors through specifications and construction documents. And, finally, the general contractors must set clear expectations for the subcontractors with thorough scopes of work.

RFPs/RFQs

Include the green requirement/goal (e.g., LEED Silver) in the RFQ for the design team. In RFQs/RFPs for design teams, require potential applicants to summarize the team's experience and qualifications in the area of sustainable building design (including experience with LEED and/or other rating systems or guidelines) and inform them that these qualifications will be considered during the selection process.

Communication During the Design Process

Clearly communicate green building documentation requirements to the design team members early in the process, especially when utilizing LEED. Remind the appropriate team members of their green building design and documentation responsibilities at team meetings throughout the various stages of design.

Specifications & Construction Documents

Because these documents are, in essence, the basis for the project implementation contracts, it is essential to include specific green building implementation, submittal, and documentation requirements (especially when using LEED) so that the general contractor and subcontractors know what is expected of them. Any green requirements should be consistently embedded within the construction documents and specifications.

LEED specifications are specialized, and off-the-shelf specifications are not effective. Clear, well-written specifications will facilitate better job control, which will reduce time delays and costs associated with change orders and callbacks. If LEED requirements are not included in the specifications, green measures will have to be incorporated later through change order. Well written specifications will also produce a more accurate and tighter bid.

Pre-Bid Meeting

At the pre-bid meeting for each project, discuss the green building requirements with the potential contractors and require that the potential construction project manager attend the pre-bid conference. The pre-bid group should be briefly walked through the LEED requirements to address any uncertainty with the process. The purpose of this discussion is to ensure that the potential bidders understand the LEED requirements and that they incorporate the costs associated with implementation in their bids. This should help to minimize risk associated with potential premiums for "bidding the unknown."

Pre-Construction Meeting

Conduct a pre-construction meeting to discuss the green building requirements with the general contractor, each subcontractor, and the green building point person. Contractor input should be encouraged during these discussions to allow for innovations and efficiencies during construction.

Green Scope of Work for Subcontractors

The general contractor or construction manager is responsible for ensuring that the environmental goals of the project are met. Thus, they should provide detailed scopes of work for their subcontractors regarding their green building responsibilities. For example, in the case of LEED, the job site waste hauler is responsible for providing the construction manager with recycling and dump tags to allow calculation of the total recycled job site waste required to achieve the Construction Waste Management credit.

Hedge Against Bad Luck

Despite best intentions, there are always some details that do not work out. For example, on the U.S. Environmental Protection Agency's campus at Research Triangle Park in North Carolina, the suppliers within 500 miles could not get some products to the site in time, and the team had to use a more distant supplier. While this project was designed and contracted before LEED was released, it would not have been able to earn the Local Materials credit despite the honest effort. When pursuing a LEED rating, be sure to include two or three extra credits in your planning process to hedge against surprises like this.

Utilize an integrated, holistic design process

Look at the project as a whole and use an integrated design process. Do not separate out the green components from the rest of the project. Integrate all the candidate green measures into the base budget. If the project is over budget, say so, and work to reduce costs overall. Avoid talking about whether the base project is on budget separately from the green measures. Establishing an integrated design process often leads to capital savings. For example, including the general contractor in early discussions with the architect and engineer may help identify ways to streamline the construction process. Involving a landscape architect early in the site planning may reduce or eliminate the need for a permanent irrigation system. An analysis of KEMA Xenergy projects found that investing 3% of total project costs during design yields at least 10% savings in construction through design simplifications and reduced change orders.[37]

Most project teams spend a lot of time identifying how much extra it might cost to build green, so they are predisposed to seeing the project as comprised of a green part atop a base project. But the reasons for adopting a holistic approach are convincing. The integrated design process can lose momentum if the team thinks it is unlikely that the green design will ever be implemented. Projects designed and built as a whole without clear demarcations between the base project and the green options are less expensive than those where the dividing line between standard and green is highlighted. This has to do with the way funding is normally allocated. Most budgeters have no experience with estimating the costs of green measures, so they create contingencies to cover the expected increase. Projects then have a tendency to grow into the new, higher budget, and the incentive to complete projects at the original, lower budget evaporates.

For a successful integrated design process:

- Make the LEED point person a true member of the team, with authority to make decisions. He or she should directly advise the A/E project manager. This person should perform LEED reviews at the same time that others perform standard reviews, acting in parallel with the standard process. It is most effective to empower this person to be a part of the change order review process, as well.
- Include contractors, property managers, real estate analysts, budget analysts, crew chiefs, and operations and maintenance staff on the design team.
- Foster and require integrated design solutions and ensure that the selected sustainable design strategies that are "whole system" in nature cannot be peeled off from the base project as "add alternates."
- Hold at least one LEED charrette led by an experienced LEED facilitator prior to schematic design. Participants should include the A/E design team and consultants, an owner's representative, building operations and maintenance staff, and the user group. Specific green-building strategies should be identified and discussed and a preliminary LEED assessment for the project made.
- The coordinator of the weekly job-site meetings should include a separate agenda item on LEED implementation requirements, documentation, and submittals to ensure these requirements are being met on an ongoing basis. The cost of these activities is small compared to the cost of correcting mistakes later.

[37] Contact Geof Syphers for more information at 510-891-0446.

Understand commissioning and energy modeling

Both commissioning and energy modeling have the potential to add significant up-front costs, however both provide essential and tangible benefits to the project design and operating budget. While the State of California supports the incorporation of a whole building commissioning process for all new construction projects, this process may add up-front costs to a project. However, benefits of the commissioning process generally far outweigh the costs, often by the time construction is complete.[38] Although whole building commissioning is preferred, it is possible to minimize up-front costs by utilizing a sampling approach to commissioning and following the LEED 2.1 guidelines on limiting the material needed on commissioning for the submittal. The new LEED 2.1 Reference Manual[39] clarifies that sampling is allowed for LEED commissioning: "…the Commissioning Authority applies appropriate sampling techniques…for example, instead of checking 100% of the controls system, which is the contractor's responsibility…" Although sampling meets LEED requirements, whole building commissioning ensures that the building ultimately operates as designed and has much greater cost saving potential over the long term.

To manage design time, invest in a good energy model early on that allows the design team to actively manipulate scenarios and explore strategies for both first-cost and operating-cost savings. A model is required by LEED to demonstrate compliance with the Minimum Energy Performance prerequisite and the savings for the Optimize Energy Performance credit. Too often, however, models are developed that meet the LEED requirements but provide very little useful planning information.

Seek out rebates and incentives

Identify utility, state, and other funding sources to help offset investments, especially in the area of energy efficiency. Utilize programs like the California investor owned utility-sponsored *Savings by Design*, which provides funding for design assistance to maximize energy efficiency of new construction and major renovation. A complete list of California statewide incentives is available online at www.dsa.dgs.ca.gov/Sustainability/incentives.htm.

Make the project a success for the decision makers

It is important to recognize that most senior decision makers are risk averse and have motivations that are not exactly the same as for PMs. To convince them to support a green-building project, it is essential to address their concerns.

Start the process by educating them in a language they understand. If possible, find one of their peers who can talk with them about their experiences with green building and/or LEED. Send them to training classes or facilitate a tour of a local project. Generally, inundating senior decision makers with convincing information is the wrong approach because they often do not have time to sift through it all and rely instead on trusted advisors to summarize the details.

Next, make a commitment to keep the project mainstream. Many green building advances are possible with proven technologies—it is not necessary to take enormous risks. It is not reasonable or feasible for most projects to achieve the equivalent of LEED Platinum.

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[38] Chad Dorgan, Richard Cox, and Charles Dorgan. 2002. Op. Cit.

[39] US Green Building Council. *LEED™ Reference Guide for New Construction & Major Renovations (LEED-NC)* Version 2.1 Second Ed., May 2003. Available for purchase at: http://www.usgbc.org/LEED/publications.asp#LEEDRefGuide.

Stay focused on the objectives of the decision makers and include them in the process. Provide the decision maker with a list of ideas for environmental technologies and ask them what they would like to see in the project. Set reasonable, achievable goals that can help the decision makers meet internal goals while improving public image.

Finally, keep budgets reasonable; most projects are not eligible for significant increases in budget, and experience shows that those projects that do receive approval for increases invariably swell artificially to fill the new budget.

Develop reasonable base case budget assumptions

Base case building assumptions are important for establishing reasonable and realistic budgets to incorporate green. For example, achieving LEED certification for a project budgeted with low-cost materials and a simple, inefficient HVAC system will likely appear to be more expensive with significant "first-cost adds" for green features. Conversely, if the project is budgeted with high-end finishes and an energy-efficient HVAC system, the incremental cost of achieving certification will appear to be much lower. In addition, some green buildings being built today are showcase projects that may include additional and sometimes costly finish upgrades that are unrelated to greenness but are nonetheless counted toward the green building cost increase. Therefore, it is crucial to plan for sustainability early on in the budgeting process: incorporate reasonable estimates for achieving the desired level of LEED certification; fairly assess which measures are being incorporated for their green components; and allocate their costs fairly.

Manage time

Collaboration in green building projects is different from the ordinary process because so many new ideas are explored.

To streamline discovery and decision-making, the following techniques should be considered:

- Select an individual (or perhaps two people) to manage the discovery process.
- Assign research topics to individuals but give them authority to create a team; if using LEED, record the lead researcher's name in the LEED scorecard next to the appropriate credit(s).
- Set a specific deadline for research results.
- Identify who the decision makers will be on large or expensive decisions before the research is completed.
- Distribute the list of known good research resources and set expectations for how much time is available from outside consultants.
- Send a summary of key research points to the discovery manager and the green building point person.
- Empower the discovery manager with the power to decide whether to cut off research or continue.

If the decision-making process is still contentious, it may be useful to bring in a mediator. However, in general, decisions are more easily made in projects where these issues are discussed ahead of time.

K-12 Public Schools

CONTEXT

California educates one-eighth of all students in America. Some 6.2 million students are accommodated in the state's public K-12 classrooms with 100,000 more added every year.[40] In response to this growth, combined with the need to retrofit existing schools and a law that limits class sizes for kindergarten through third grade, the state is investing $50 billion over the next 10 years to build 400 new schools despite the budget crisis.[41] Despite the need to provide adequate facilities for a growing number of students within a very strict timetable and with limited funds, it is still possible to design and construct high performance schools. Ultimately a decision to invest in high performance schools will save the state operations and maintenance, replacement, and retrofit costs. However, in some cases, designing and constructing high performance school does require some level of additional up-front investment. This chapter therefore provides specific cost management strategies for high performance K-12 schools that build on the guidelines presented in the General Strategies section.

Because of the large amount of new construction planned, the state has an opportunity to significantly improve the quality of its schools by building this new generation better than the last: schools with low operating costs, clean air, and good daylighting. The recent Build California initiative focuses on quickly releasing funding for infrastructure projects, including school bond funds, while responding to high performance design issues. The Division of the State Architect has embraced these high performance principles for schools and in response has recently launched its "Sustainable Schools" website to provide resources for districts.[42]

Many studies demonstrating the value of green building provide additional support for greening California schools. Among other topics, these studies show that daylighting in classrooms result in improved test scores,[43,44] and characterize the indoor environmental quality concerns of typical relocatable classrooms.[45] Given the interest in fiscal and environmental conservation, California government is exploring green building guidelines that support the multiple goals of energy and water conservation, indoor air quality, reduced waste and lower operating costs.

K-12 Schools: LEED and CHPS

School districts can use the LEED and CHPS green building rating systems to help improve the quality of their buildings and the health of their students and staff. The two leading rating systems

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[40] Data supplied by the California Department of Education, See: www.cde.ca.gov/demographics

[41] Statistics supplied by the Collaborative for High Performance Schools, See: www.chps.net.

[42] California Department of General Services, Division of the State Architect. Sustainable Schools Website. See: www.sustainableschools.dgs.ca.gov/sustainableschools.

[43] Heschong Mahone Group. *Daylighting in Schools: An Investigation into the Relationship between Daylighting and Human Performance*, 1999. Available at: http://h-m-g.com (see featured projects).

[44] Heschong Mahone Group. *Daylighting in Schools, Additional Analysis*, 2002. Available at: www.newbuildings.org/pier.

[45] Mike Apte, et al. *Energy and Indoor Environmental Quality in Relocatable Classrooms.* Prepared with Public Interest Energy Research Funding, per California Energy Commission contract 400-99-012, Element 6. Available at: www.energy.ca.gov/pier/buildings/technical_papers/EnergyIEQClassrooms.pdf.

are very similar—CHPS was developed as a modification of LEED—but they differ in important ways. The fundamental distinction between the two systems is that CHPS guidelines are explicitly focused on K-12 school construction in California while LEED is a national system intended for a wide range of project types.[46] For these reasons, CHPS is a better fit than LEED for most California schools. Despite its shorter existence, CHPS surpasses LEED in popularity among school projects in California.[47] This section therefore focuses more heavily on CHPS than LEED.

Table 7 is a summary of the major differences between LEED and CHPS:

Table 7. CHPS Criteria vs. LEED™ NC 2.1 Rating System

CHPS	LEED NC 2.1
Simple pass/fail system	4-tier ranking system (Certified, Silver, Gold, Platinum)
Schools only	All nonresidential building types
Self-certifying	Formal application and review process
California Title 24[†] energy baseline	ASHRAE 90.1 or California Title 24 minimum compliance baseline
Prescriptive methods for energy credits	Energy simulation required for energy credits
Prescriptive options for most credits	Calculations and/or simulation required for some credits
Fundamental commissioning is a credit	Fundamental commissioning is a prerequisite
Minimum acoustic performance prerequisite	No acoustic performance baseline or credit
Credits for District Resolutions	No District Resolution credits
Strict low-emitting materials specifications	Prescriptive low-emitting materials compliance
81 possible points; 28 required for a HPS[‡]	69 possible points; 26 required for base certification

[†] *Title 24 is California's energy code.*
[‡] *HPS stands for High Performance School*

The major differences between CHPS and LEED are further explained below:

- CHPS' pass/fail system simplifies the certification process—a school is either "High Performance" or not. Unlike LEED, there are no different levels of certification. The pass/fail system allows for the most flexibility for the design team while also setting a performance expectation. It also keeps costs low, as the passing mark is relatively easy to achieve for most projects without a significant additional capital investment. However, some districts, like the Los Angeles Unified School District (LAUSD) recognize value in the CHPS credits and are considering making some level above a CHPS passing grade the standard.
- Prescriptive elements: CHPS prescribes minimum values for measures, thereby simplifying the process of meeting a credit. For example, carpets must have at least 50% recycled content to qualify. Products either meet this minimum requirement for recycled content, or do not qualify for the credit. No calculations are needed. LEED, on the other hand, requires a complex weighted average calculation to determine compliance.

[46] CHPS Volume II Best Practices Manual was adapted from national standards in "National Best Practices Manual for Building High Performance Schools," Available at www.energysmartschools.gov.

[47] At time of researching this paper, only four California K-12 LEED projects were registered on the USGBC's website, see Registered Projects, www.usgbc.org/LEED/Project/project_list_registered.asp; CHPS had 15 according to their project lists at www.chps.net/chps_schools.

- Commissioning requirements: CHPS encourages commissioning, but does not make fundamental building commissioning a prerequisite as in LEED. CHPS schools must have "systems testing and training" in which a third party or district official must verify that building systems have been tested prior to occupancy, including controls, HVAC and EMS. CHPS also requires staff trainings and guidebooks. Commissioning is a capital cost add that automatically comes with LEED but that is optional in CHPS. There are, however, significant benefits associated with commissioning, including recovered capital costs. Therefore, although commissioning is not a prerequisite in the CHPS system, schools should still consider requiring this credit for all facilities. The DSA has developed a commissioning protocol for schools to use when building new, or retrofitting old, facilities.[48]
- Acoustical performance: CHPS requires all classrooms have maximum unoccupied background noise levels of 45 dBA and 0.6-second maximum reverberation times. LEED has no acoustical requirements. Acoustics are particularly important in classroom environments and may positively or negatively affect capacity for learning.
- Low-emitting materials specifications: CHPS relies on a very strict specification (California Section 01350) as the testing method for materials.[49] LEED, on the other hand, relies on third-party verification that products meet specific testing protocols and regulations, such as GreenSeal for carpets. The CHPS performance specification, Section 01350, is much more difficult to achieve than the LEED standards; CHPS requires a minimum level of offgassing in a given time period when air is flowing across the material.
- District resolutions: points are awarded to a building in a district that has sustainable measures or requirements already in place. LEED does not include similar credits.
- Unlike LEED, CHPS is self-certifying. The inherent costs associated with LEED registration and documentation makes it less attractive than CHPS to some school districts. Because CHPS certifications are not reviewed by a third party organization, however, green design can potentially be trivialized and is more likely to be seen as an "extra."
- LEED's four-tiered system encourages competition, rewarding higher ratings for achieving more points, while CHPS sets a sensible but effective threshold.

As of October 2003, six K-12 school districts and one community college district had adopted the CHPS guidelines for their future projects, including the Los Angeles Unified School District (LAUSD), the second largest district in the nation. San Francisco Unified School District, San Marcos Unified School District, San Rafael City Schools, Santa Ana Unified School District and the Dry Creek Joint Elementary School District have also adopted some form of CHPS as the criteria for building new schools.[50] There were 10 demonstration schools being built to the CHPS

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[48] Farnsworth Group. *Adopting the Commissioning Process for the Successful Procurement of Schools: Receiving Value for the Community's Investment.* Prepared for the California Department of General Services, Division of the State Architect. January 2003. Available at: www.dsa.dgs.ca.gov/comm_process_guide.htm.

[49] State of California. Special Environmental Requirements Specification, Section 01350. See www.ciwmb.ca.gov/GreenBuilding/Specs/Section01350.

[50] School districts that have developed and passed district resolutions are listed on the CHPS website: http://chps.net/chps_schools/districts.htm.

guidelines under construction and five more registered on the CHPS website for future development.[51]

In comparison, according to the USGBC website in October 2003, there were nearly 70 registered K-12 schools, nationally. Only four of those schools have been certified, none in California. In fact, California projects make up only four of the 70 registered projects.[52] Of the four in the state, the York School Science Building in Monterey is farthest along and expects to achieve a Silver rating by early 2004.[53] With three LEED registered projects and 15 CHPS registered or completed projects, CHPS seems to be the preferred standard for designing green school buildings in California, despite its more recent release.

Project teams cite CHPS' relaxed certification process, lack of registration and documentation fees, and less-stringent prerequisite credits as reasons for selecting CHPS over LEED for K-12 schools. A recent paper documenting the LAUSD experience with CHPS indicates that CHPS should be the preferred green building standard for school districts adopting green building guidelines:

> "Select CHPS over LEED: CHPS is a better choice than LEED for school districts, as long as safeguards are put in place to ensure that the program is implemented…. CHPS includes almost every LEED criteria relevant to schools…and it is less expensive to implement because the paperwork requirements are much less onerous."[54]

The York School Science Building in Monterey is a private school, and chose to use LEED because staff felt that CHPS is better suited to *public* school projects; funding, budget structure and absence of state review boards render private schools more similar to commercial development than their public counterparts. Early estimates for this project indicated that green materials would cost 15% above "standard" materials. Completed in 2003, however, the project came in on budget.[55] The project team is not able to pinpoint the cost of the entire LEED package because the non-material costs are difficult to track, as they were integrated fully into the total design and construction costs.

Cost issues

Schools are often built of the least expensive materials and systems possible. In California this often translates into single-story wood framing with stucco finish. A high performance school, however, may incur costs above this base model; daylighting, open ceiling plans, high efficiency lighting and mechanical equipment, natural ventilation and other measures typically add capital cost. However, these and other high performance upgrades pay for themselves over time through energy savings, reduced maintenance, and increased student performance and attendance. Not all strategies have to add cost, however. Many architects, school district officials, and members of the Collaborative for High Performance Schools indicate that high performance schools can be

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[51] For updated information and district resolutions, see CHPS Schools web page: www.chps.net/chps_schools/index.htm.

[52] Goodwillie Environmental School, Ada, MI; IslandWood, Bainbridge Island, WA; John M. Langston High School Continuation and & Langston-Brown Community Center, Arlington, VA; and Third Creek Elementary School, Statesville, NC have been certified. See https://www.usgbc.org/LEED/Project/project_list.asp for the updated list.

[53] Communication with Ken Scates of HGHB Architects.

[54] From "Implementing CHPS: the Los Angeles Unified School District Experience" prepared by John Zinner, Zinner Consultants, Feb. 2003. Available at: www.usgbc.org/chapters/losangeles/docs/pdf/ZinnerJohn_2003.pdf.

[55] Communication with Ken Scates of HGHB Architects.

built within reasonable budgets. The challenge is somewhat greater when the decision to use CHPS is made for projects that are already contracted.

The LAUSD is looking at strengthening their CHPS resolution to specify some level of certification beyond minimum compliance because they feel that the 28 points required for CHPS certification is not strict enough to ensure the delivery of high performance facilities.[56] The school district has discovered that, when considering capital and operational costs together, CHPS certification does not add any cost to projects. Projects incur additional costs from increased design time, architectural fees, and analysis, but the total project costs are not higher than with conventional construction.

Individual green building measures may increase project costs when considered in isolation. Increased glazing areas, high performance windows, skylights, and better quality finish materials may add cost and extra design time. Even though schools sometimes can factor in long-term costs, districts often have difficulty justifying higher capital costs for green attributes. Some low-cost strategies, such as proper orientation of a building on the site, only indirectly receive LEED or CHPS credits, despite the fact that they contribute substantially to energy conservation and other relevant goals.

Relocatable Classrooms (a.k.a. "Portables")

Currently one third of all California K-12 students attend school in relocatable classrooms.[57] Portable buildings have the benefits of lower cost and rapid delivery. Unfortunately, most of these classrooms have problems with temperature control, adequate ventilation, lack of daylight, poor acoustics and substandard durability. A recent report published by the California Air Resources Board and the California Department of Health Services stated that air in portable classrooms is more likely to contain harmful levels of toxic chemicals than the air in permanent classrooms.[58] This same report found that many portables do not meet minimum ventilation requirements set by the state, therefore this group of facilities should be specifically targeted for improvements.

Standard finish materials have offgassing problems, and noisy ductwork coupled with inadequate airflow cause ventilation and acoustic problems in portables. The Alameda County Waste Management Authority's research into healthy portables found that some new portable classrooms are not designed to accommodate the ventilation rates necessary for a full classroom. Most portable classrooms tend to be heated and cooled by noisy rooftop or wall-mounted package units and the California Air Resources Board and California Department of Health Services study found that teachers tend to turn off the HVAC systems due to noise. Limited glazing decreases daylighting and natural ventilation opportunities, and mold problems sometimes arise from lack of maintenance and poor planning. In one case, a California school installed portables over active sprinklers and did not discover the problem for weeks.

Despite the drawbacks, portables will continue to be installed on school campuses because of their low initial cost. In California, construction costs are increasing while state funding in dollars-per-square foot is decreasing making it difficult for schools to build quality structures.[59] It

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[56] Communication with Angelo Bellomo, Director of Environmental Health and Services at the LAUSD.

[57] Collaborative for High Performance Schools, See: www.chps.net.

[58] California Air Resources Board and the California Department of Health Services. *Report to the California Legislature, Environmental Health Conditions in California's Portable Classrooms.* June 2003. Available at www.arb.ca.gov/research/indoor/pcs/leg-report/leg-report.htm.

[59] Communication with Rob Samish, architect on the CHPS demonstration Truckee School and Tom Burke of HMC Architects, designers of the CHPS demonstration San Pasqual Elementary school.

is common for districts to scrap plans for their classroom buildings and convert the project entirely to portables.

For schools installing relocatable classrooms, a number of measures can be implemented to minimize indoor air hazards, including:

- HVAC and ventilation system upgrades;
- Formaldehyde-free insulation;
- Natural linoleum instead of vinyl flooring;
- Increased area of operable windows;
- Skylights and other daylighting strategies integrated with lighting controls;
- Zero-VOC interior paint;
- Elimination of carpeting or use of third party tested and approved products.[60]

Most of these strategies will add up-front costs to a standard portable module, but the cost may be less than expected. According to the Alameda County Waste Management Authority, a new portable can be factory-built with skylights, upgraded HVAC and ventilation system, increased duct insulation for acoustics, zero-VOC paint, and non-CCA treated wood for less than $5,000 additional cost.[61]

Nonstandard practice

Non-standard construction practices can slow down projects and increase costs. On the LEED registered York School Science Building,[62] the architect had difficulty with implementing construction practices that were neither new nor risky, but were simply not common. The York School used high-volume flyash to replace a portion of Portland cement in the concrete on the project. The result was a better product, but the project team had to invest a major effort to convince local inspectors to sign off on the concrete work because use of flyash was not common practice in their area.[63]

Although not all schools incorporate every green technology, water-free urinals are one of the most visible examples of a new technology creating a barrier to green school construction. These urinals offer direct benefits to schools due to reduced maintenance costs and water savings. Even if the urinals get past local government review—which can be difficult—maintenance staff and school districts may oppose them. Some projects, such as the El Segundo High School,[64] have installed water-free urinals, but they are still rare, despite the benefits.

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[60] Green Label is the Carpet and Rug Institute's indoor air quality testing program, www.carpet-rug.com. Other third party certification processes include the use of Section 01350, described at www.ciwmb.ca.gov/greenbuilding/Specs/Section01350. Scientific Certification Systems new carpet standard specification for environmentally preferable carpet is available from www.scscertified.com/carpet/mfg_CarpetSCSEPP1103a.doc.

[61] Standard cost for a portable prior to high performance upgrades is approximately $40,000, data provided by the California Office of Public School Construction, May 2003.

[62] The York School is located in Monterey, CA.

[63] Communication with Ken Scates of HGHB Architects.

[64] Communication with Risa Narita and Jorge De La Cal of Anshen and Allen Los Angeles.

Rating systems are still new

While the LEED rating system is still relatively new, CHPS is newer still, officially launched in 2002. The newness of these rating systems can lead to increased planning and design time, ranging from deciphering the intent of a credit to researching new products. CHPS managers and project teams continue to discover areas that need additional interpretation, often leading to delays. In one case a team specified an acoustical ceiling product containing 79% recycled content, barely missing the 80% recycled content required by CHPS.[65] Over time, as CHPS and LEED develop further, these issues will be resolved.

MANAGING COSTS

A number of strategies can be incorporated at every level, from policy through design and construction, to help limit costs on green school projects.

Pass a district resolution

In keeping with the general strategy of setting clear expectations, school districts can pass resolutions establishing goals for high performance, sustainable school design and construction. Such resolutions may require the use of CHPS for all major new construction: 6 districts throughout the state have already passed such resolutions. This helps streamline the design and construction process because the requirements, while new to some, are all well defined and easily researched. A clearly written resolution helps eliminate uncertainty that can complicate and add cost to a design process; simplify value-engineering decisions; and help to answer questions during construction. By committing to using CHPS on multiple projects, districts may also be able to leverage their buying power with suppliers and vendors over time, especially if vendors of high performance materials and equipment know that the districts will not change their specifications during construction. According to CHPS literature, the following additional benefits can also result from adopting a district-wide resolution:[66]

- Up to 10 CHPS points, making a CHPS rating more easily obtainable;
- Guaranteed realization of CHPS benefits, including reduced maintenance & operation costs; and
- A partially filled out CHPS scorecard from the start of the project.

Facilitate a smooth review process

When new public schools are built in California, state funds cover half of the project cost and the local school district provides the other half. Though the state does not provide funding for private school construction, both public and private schools must undergo extensive reviews, including public reviews, district reviews, municipal reviews and, for public schools, state reviews. As a result, schools projects can take a long time. Without a politically savvy team, the review process is costly and takes more time.

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[65] Conversations with Rob Samish of LBDG.

[66] See: CHPS Schools: www.chps.net/chps_schools/districts.htm

Stage agencies like the State Allocation Board, the Office of Public School Construction, the California Department of Education, and the Division of the State Architect (DSA) have requirements that can delay or add to the scope of a project. Local agency requirements, from planning to fire and health departments, can also impact schedule and budget. One school district, for example, cites protrusions and vegetation close to buildings as a pest concern because of nesting and access for rats. The district's integrated pest management policy does not allow light shelves or certain shade trees, for example, even though the district also promotes daylighting and energy-saving strategies for schools.[67]

Project teams should thoroughly understand how school construction is regulated in California and in their local jurisdiction. Districts should hire architects and other consultants who know the rules and rule interpretations from all of the various state and local agencies. Consultants should submit complete work for reviews—not incomplete drafts—and know how to negotiate with the regulatory agencies on behalf of their projects. Important on any job, this knowledge can be even more critical when green ideas are in question, especially in districts that have no prior experience with green design. The design team must be able to defend their green ideas and articulate the reasons for their designs and should be comfortable, for example, citing studies correlating daylighting elements with IAQ and test score improvements, or explaining the benefits of utilizing an on-site greywater system.

The California State Allocation Board recommends that project teams get involved with the various state and local agencies by going to meetings, learning the processes and visiting their websites.[68] Regulatory agencies, although they may sometimes have competing priorities, still have the overall goal of high performance design; they design their rules to help create safe, healthy learning environments. Design teams should use the language in these goals to articulate the value of green measures instead of inventing convincing new arguments.

In some cases, project teams may find that regulations work to their benefit, furthering green building goals. For the modernization of El Segundo High School, a CHPS demonstration project in Los Angeles, the DSA allowed the project team to use the shell of the old building despite normally requiring an updated structure. Because the project was a voluntary remodel, with no seismic or safety issues, the DSA allowed the team to salvage some of the core and shell, diverting waste and achieving credits under CHPS. [69]

Use green to help define school image

To create a unique image or fit a district theme, some schools add elaborate layouts or expensive finishes.[70] Instead, architects can use green elements to achieve both health and environmental objectives while creating architecturally distinctive schools. For example, carpet can be installed on the walls for acoustic benefit while leaving the floor bare concrete, making the floor much more durable and giving the building more character.

All of the CHPS demonstration schools as well as the LEED Certified K-12 schools use green building as the unifying theme of the school. While the overall image of the project does not have to reflect green design priorities, design teams working on the CHPS demonstration projects found that elevating green as a central project theme helped simplify their designs and save cost. The buildings are designed to both look and function differently from conventional schools. The

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[67] Communications with John Zinner of Zinner Consultants.

[68] California State Allocation Board, *Public School Construction Cost Reduction Guidelines*, 2000. Available at: www.documents.dgs.ca.gov/opsc/pdf-handbooks/CostRedctnsGuidlines.pdf.

[69] Communication with Risa Narita and Jorge De La Cal of Anshen and Allen Los Angeles.

[70] California State Allocation Board. 2000. Op. Cit.

daylighting design of the Georgina Blach Intermediate School in Los Altos, for example, includes large sliding glass doors that can be opened in good weather to allow sunlight and fresh air into the space.[71] The El Segundo High School, in El Segundo, California, utilizes a progressive landscape plan with the dual purpose of reducing stormwater runoff and adding character to the school. In the York School Science Building, deep overhangs on the south elevation were exaggerated to showcase the green design intentions. The High Tech High School in the San Fernando Valley is a state-of-the-art building designed to look like a contemporary technology research center. This theme allows for creative use of architectural glass, metal components, and mechanical systems that can be used as finish materials while contributing to daylighting and high efficiency HVAC systems.

A building that utilizes green methods outlined in LEED or CHPS can, if desired, easily develop a style and signature that is both unique and beneficial. If budgets are tight, keep buildings and layout simple, but make green building and IAQ strategies the prevalent theme in school design.

Beat California Energy Code by at least 15%

Districts should set an energy performance goal of beating California's Title 24 energy efficiency code by at least 15% and help design teams to meet it. Many engineers assume that to meet this goal, they must include expensive upgrades to HVAC equipment and lighting. While that is occasionally the case, generally it is not. With current code, a 15% improvement is quite reasonable with intelligent design. Further, a stringent energy performance goal sets a high threshold for efficient equipment and can lead to a critical evaluation of building orientation, shell design, and HVAC and lighting controls that can collectively save capital costs by simplifying shell elements and downsizing HVAC equipment. Proper orientation and configuration leads not only to energy savings but also to improved natural light and ventilation. Finally, by beating energy code allowances by 15%, projects are eligible for the statewide incentive program, *Savings by Design*. This program provides incentive money for some of the equipment upgrades, daylighting and ventilation studies, and energy consultation.

Evaluate all appropriate daylighting options

Despite proven benefits, daylighting strategies may be difficult to implement because project teams are most familiar with expensive options. Daylighting is not an all-or-nothing endeavor, however, and architects should consider a range of options, balancing costs and benefits, before making decisions. Proper orientation can be one of the least expensive strategies to maximize daylighting. Combined with appropriate overhangs, proper orientation can reduce glare, bring in light and heat, or keep it out where desired.

To ensure proper orientation, select architects that have a proven understanding of daylighting and solar orientation. Make a point of asking about their experience in these areas in RFPs and during interviews. Make use of free local energy efficiency centers. Some, like the Pacific Energy Center in San Francisco, have a solar simulator to model daylighting and staff to provide technical assistance.

Only after ensuring good orientation, glazing distribution, appropriate overhangs, light shelves and shade should the design team consider technical solutions like dimmable lighting systems. For the 11 CHPS demonstration projects researched in this paper, only two eliminated the drop-ceiling plan to open up classrooms and allow for clerestory windows.[72] The extra cost of clere-

[71] Walter Yost. "School looks to the future," *The Sacramento Bee*, June 5, 2003.

[72] See: www.chps.net.

story windows and structural ramifications of raising the south wall to capture more daylight is often cost prohibitive.

By taking the time to explore simple options to bring daylight into classrooms, inexpensive solutions are usually possible. If the building is oriented properly, daylighting is much easier and less expensive to integrate. Lighting produces a significant amount of heat that needs to be offset by the cooling system. By aggressively eliminating the need for electric lighting, a building's cooling system may be downsized, helping offset costs of daylighting strategies.

The Southeast Learning Center in Huntington Park was built with a conventional budget yet it uses 30% less energy than allowed by California's Title 24 energy code, mostly because of its advanced daylighting strategies. Though some specific elements added cost, integrated design enabled the team to buy increased insulation, better windows and premium efficiency equipment by downsizing HVAC equipment and simplifying the design.[73] Specific design elements include an open ceiling plan, dimming systems and controls, indirect/direct fixtures, and tubular skylights that penetrate all three stories. The design also incorporates switches that turn off air conditioners when windows are open. Long-term costs to the school will be much less than for a standard school because of significant energy savings.

The Truckee School could not utilize skylights or light shelves because of snow loads on the roof. Still interested in incorporating daylighting, the design team used a creative approach to reflect natural light onto the ceiling of the classrooms. They placed standard but inverted mini-blinds between two panes of glass, which created a light-shelf effect, bouncing light up to the ceiling and providing high quality diffuse light to the classroom space.[74]

Design buildings that teach

Schools are a teaching environment and should be teaching tools themselves. The York School Science Building was designed to serve as a part of the teaching curriculum. The shape and orientation of the building is exaggerated to highlight sustainable elements. The classrooms' high ceilings, high windows and deep overhangs stand out as important features. There are windows cut into sections of the ceilings and walls, explicitly showing the advanced framing techniques and alternative insulation materials utilized in construction. The photovoltaic system includes an interactive display which students programmed to report real-time energy generation.

Just as meeting energy and disability access codes add cost, these green elements also add cost. But like the energy and ADA requirements, they also add significant value. A recent issue of Environmental Building News discussed the importance of green school construction, noting:

> "In many respects, schools should be our highest priority of any building type for greening. The importance of our children's health, the significance of school buildings in a community (both financial and cultural), and the potential for school buildings to serve as tools to teach sustainability all argue for devoting effort toward making these buildings green."[75]

Leverage incentives and free assistance

Several programs are available to new construction and renovation projects that can help offset design costs and equipment upgrades, and provide modeling and analysis on green building

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[73] Communication with Herta Gaus of WLC.

[74] Communications with Rob Samish of LBDG and referenced in the *Sacramento Bee* article "Back to Nature: Schools use green technologies to save energy – and money", June 5, 2003.

[75] Alex Wilson. "Green Schools: Learning as We Go." *Environmental Building News*. Volume 11 Number 11. Available at: www.buildinggreen.com/ebn/toc11.cfm#no11.

projects. For schools, these programs can provide financial assistance or simply help to verify the feasibility of some high performance measures, such as using integrated design to reduce lighting levels or air conditioning loads. Some of these programs are:[76]

- **Savings by Design (SBD)**[77] is a program funded by the Public Goods Charge and run by the Investor Owned Utilities that promotes energy-efficient design in new construction and renovation projects with financial incentives and technical resources for designers, contractors, and building owners. Projects can receive assistance by designing for 15% energy savings over existing Title 24 regulations.
- **Bright Schools**[78] is a state-sponsored program through the California Energy Commission that provides up to $20,000 toward technical assistance from experienced engineering and architectural consultants for school energy audits and retrofits. Bright Schools can also help project teams secure low-interest loans for energy efficiency upgrades.
- **California Energy Commission grants**, in addition to Bright Schools, may also be available. Two CHPS demonstration schools received CEC grants.

Nearly all of the K-12 school projects reviewed for this report received some form of incentive for energy efficiency upgrades. Southern California Edison funded studies on El Segundo High School through their Savings by Design program. SBD provided the school with the opportunity to test designs, enabling them to take risks that otherwise might not have been acceptable. SBD also provided energy modeling, natural ventilation and thermal mass studies, and payback analyses for various energy scenarios. The El Segundo school utilizes a mixture of natural and mechanical ventilation, and some portions of the campus require no mechanical cooling due to the integration of thermal mass and passive cooling techniques. SBD assistance allowed the team to model the effects of the thermal mass on building energy consumption. In part of the building, architects originally designed block walls to increase thermal mass for passive cooling. However, SBD studies showed that this was an unnecessarily conservative strategy; the architects were able to design for standard stud walls instead, saving money. SDB tests also confirmed for the District that the design elements improved building performance and were cost-effective.

In another demonstration project, SBD provided incentives that helped the San Pasqual Elementary school keep high efficiency windows and efficient package rooftop units from being value engineered out of the project.[79]

The Truckee Middle School received a $250,000 grant from the California Energy Commission to help offset a $500,000 geothermal heat pump system. The unusual project site on a hillside in the Sierra Nevada Mountains allowed the building to reap the benefits of a geothermal ground source heat pump. With the incentive, estimated payback is about eight years.[80]

Design-build contracting

The California Legislature enacted bill AB 1402 in 2002, giving some schools the ability to hire design-build firms for school construction.[81] Before AB 1402, schools were typically constructed

[76] For a complete list of programs available in the state, see: www.sustainableschools.dgs.ca.gov/sustainableschools.

[77] Savings By Design information can be obtained at www.savingsbydesign.com.

[78] Bright Schools information found at www.energy.ca.gov/efficiency/brightschools.

[79] Communication with Tom Burke of HMC Architects.

[80] Communication with Rob Samish of Lionakis Beaumont Design Group (LBDG) and Claudia Orlando of the California Energy Commission.

[81] State of California. Education Code. Chapter 421, Statutes of 2002. Assembly Bill 1402, available at: www.leginfo.ca.gov/pub/01-02/bill/asm/ab_1401-1450/ab_1402_bill_20011002_chaptered.html.

using a design-bid-build model. AB 1402 represents a significant change in the funding mechanism for building schools. The bill enables school districts to retain any savings that might result from building new schools with the design-build process.[82]

Ensure proper commissioning by school district

Project teams should begin to consider the impact of commissioning early in the design process, regardless of the level of commissioning implemented. Both CHPS and LEED require levels of basic commissioning and give additional credits for advanced commissioning, but school districts may eliminate it during value engineering if not pursuing these ratings. Proponents of green building within school districts should seek out information on commissioning and help educate district decision makers on the benefits of commissioning.

The CHPS commissioning requirements do not mandate a third-party commissioning agent, and the scope of commissioning services is less than required by LEED. As a result, the CHPS level of commissioning can be inexpensive, yet will likely add significant value.

RESOURCES

General Resources

California Department of General Services, Office of Public School Construction. *Best Practices: A Sampling of the Best Practices and Resources of School Facility Construction*, 2003. Available at: www.opsc.dgs.ca.gov.

The Collaborative for High Performance Schools (CHPS). The CHPS website has a library of resources for HPS, including links to recent news, district resolutions, IAQ studies, and downloads for the Collaborative for High Performance Schools (CHPS) Best Practices Manual Volume I-III. See: www.chps.net.

Heschong Mahone Group. *Daylighting in Schools – An Investigation into the Relationship Between Daylighting and Human Performance*. Prepared for Pacific Gas and Electric Company and funded by California utility customers. 1999. Available at: http://h-m-g.com/ (see featured projects).

Heschong Mahone Group. *Re-Analysis Summary: Daylighting in Schools, Additional Analysis*, Prepared on behalf of the California Energy Commission PIER program. 2002. Available at: www.newbuildings.org/pier.

Mills, Daryl, Charles Eley, et al. "The Collaborative for High Performance Schools: Building a New Generation of Sustainable Schools. Proceedings of the *ACEEE 2002 Summer Study on Energy Efficiency in Buildings*, Washington, D.C. Available at: www.energy.ca.gov/papers/2002-08-18_aceee_presentations/PANEL-06_MILLS.PDF.

California State Allocation Board. *Public School Construction Cost Reduction Guidelines*, Prepared by the Office of Public School Construction, 2000. Available at: www.documents.dgs.ca.gov/opsc/pdf-handbooks/CostRedctnsGuidlines.pdf.

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[82] California Department of General Services Office of Public School Construction. *Best Practices: A Sampling of the Best Practices and Resources of School Facility Construction*, 2003. Available at: www.documents.dgs.ca.gov/OPSC/pdf-handbooks/best_practices.pdf.

San Rafael City Schools District. *Resolution #1088 in Support of CHPS Criteria for School Construction and Modernization*, May 5, 2003. Available at: www.chps.net/chps_schools/districts.htm.

The State of Pennsylvania Governor's Green Government Council's Green Building Video Series, Available at: www.greenworks.tv/green_building/archives.htm.

Wilson, Alex. "Green Schools: Learning as We Go." *Environmental Building News*, Volume 11 Number 11, November 2002. Available at: www.buildinggreen.com/ebn/sum/11-11.cfm.

Yost, Walter. "Back to Nature: Schools use green technologies to save energy – and money." *Sacramento BEE*, June 5, 2003. Available at: www.ttusdprojects.org/NEW%20MIDDLE%20SCHOOL/Sac%20Bee%20article.pdf.

Yost, Walter. "School looks to the future." *Sacramento BEE*, June 5, 2003.

Zinner, John. *Implementing CHPS: the Los Angeles Unified School District Experience*. February 2003. Available at: www.usgbc.org/chapters/losangeles/docs/pdf/ZinnerJohn_2003.pdf.

IAQ Resources

California Air Resources Board and the California Department of Health Services. *Draft Report to the Legislature: Environmental Health Conditions in California's Portable Classrooms*, June 2003. Available at: www.arb.ca.gov/research/indoor/pcs/leg-report/leg-report.htm.

The Environmental Protection Agency's Indoor Air Quality (IAQ) Tools for Schools Kit. Available at: www.epa.gov/iaq/schools/toolkit.html.

The California Air Resources Board and Department of Health Services, *Remedies for Reducing Formaldehyde in Schools* , March 2002. Available at: www.arb.ca.gov/research/indoor/formald1.htm.

Funding Information

Bright Schools Program, California Energy Commission. See: www.energy.ca.gov/efficiency/brightschools.

California Department of General Services, Division of the State Architect. *Sustainability – Financial Incentives*. Sustainable Schools Website. . See: www.dsa.dgs.ca.gov/Sustainability/incentives.htm.

Sustainable Schools Website: The California Division of the State Architect has set up a comprehensive website for finding resources on greening schools. Start any research into CHPS or LEED school funding at this site. See: www.sustainableschools.dgs.ca.gov/sustainableschools.

The Database of State Incentives for Renewable Energy (DSIRE). See: www.dsireusa.org

Savings By Design incentive program. See: www.savingsbydesign.com.

Public Libraries

CONTEXT

Libraries, with their broad public access, and focus on community information and activism, are natural places to introduce new ideas such as environmentally responsible design. Since libraries are built to last a long time, their design should reflect the long-term benefits of sustainable construction. This chapter provides specific cost management strategies for public libraries that build on the guidelines presented in the General Strategies section.

A library's daily operation can be profoundly improved by sustainable design. As public spaces, libraries should be memorable, healthy, comfortable and inviting; they should encourage reading and learning, and draw users back. Green designs can help create this kind of space.

Libraries also require carefully controlled interior environments to preserve collections and to provide a comfortable setting for research and teaching. Air quality, temperature, and humidity levels must be held within narrowly specified ranges. The lighting, thermal comfort and control, indoor air quality, and other program elements important to a well-conceived library, are also important factors in green design. In most cases, libraries must accomplish all this within a very thin capital budget while also keeping operating costs as low as practical. Green design should be used to promote operational savings by lowering maintenance and energy costs and increasing user efficiency.

Libraries and LEED

Libraries built and operated sustainably provide environments that best serve library program missions, reduce dependence on overtaxed energy and water delivery systems, and demonstrate an important direction for planning, construction and operation of other publicly owned facilities. Documenting the benefits of green design and construction with a system such as LEED is essential to understanding, communicating, and replicating the achievements of green building.

LEED is the primary rating tool and guideline now used for greening public libraries. However, most projects have tight budgets that do not have room for increased construction costs or special documentation. In most cases, registered libraries that are currently in the construction phase are pursuing LEED under the direction of their respective governments (cities, counties, universities). These government owners provide motivation and leadership, either because they are following local ordinances, or are trying to present consistency with an overall environmental program or mission.

Cost issues

As of October 2003, there were no LEED-certified library buildings to analyze. However, 51 libraries and projects with library components are registered for future certification.[83] Due to the rapid success of LEED in penetrating the municipal building market, the number of LEED-registered library projects is expected to increase significantly over the next couple of years. In

[83] US Green Building Council. *Registered Projects.* See: www.usgbc.org/LEED/Project/project_list_registered.asp

addition, many of the current LEED-registered library projects should be completing construction within that time, thus creating a larger pool of cost data.

Absent cost data from LEED-certified projects, local cost-estimating consultants and project managers were interviewed to find this information. There was wide agreement that a LEED Certified library with a reasonable base budget is achievable without significant cost provided the decision to pursue greening is made early in design.[84] Library project managers interviewed for this report confirmed that the range of observed incremental costs for each LEED rating level provided in the *General Strategies* section coincided well with their projects with one exception. The team designing the West Valley Branch Library in San José incurred additional project costs of more than 6% as a result of the city's decision to pursue a LEED Certified rating late in the design process (after 50% CDs).[85]

Municipal standards and processes

Many library projects include standardized design elements within a city or county, (e.g., siting, building footprint, materials). While designing and building green libraries can be difficult under normal circumstances, the additional requirement of having to challenge a predefined status quo can make designing and building green libraries even more challenging.

Local codes

Some city codes run counter to best sustainable practices. For example, many municipalities require on-grade parking lots of either concrete or asphalt instead of supporting alternative permeable surface materials. Alternative mechanical systems (i.e., those other than electric powered roof-mounted "package" units) are often not part of a city's standard maintenance practice, and so city staff often discourage their use. In addition, local codes may prohibit resourceful measures that are not common practice, especially concerning water efficiency and natural ventilation. In many Bay Area jurisdictions, water-free urinals, rainwater catchment systems, greywater reuse systems and dual-flush toilets are prohibited by code, despite their proven successes. Though these measures are very effective at saving water—a stated goal of most municipal agencies—they typically can only be included in a project with the necessary variances.

Inflexible budgets and bond funding

Municipal operations and capital budgets often tend to be allocated through separate processes and even derived from different funding sources. As a result, it is usually challenging to transfer funds between the two accounts. This is a significant barrier to implementation of many green practices, especially those that might cost more up front, but save money over the life of the building.

The purchase of energy efficient equipment to optimize energy performance provides a good example of lifecycle savings. Although the energy efficient equipment might be more costly up front, it will typically provide significant operational savings over the life of the equipment (and maybe even pay for itself within a few years). It would appear that incorporation of these efficiencies would be an easy decision for a municipality with the ability to consider longer-term

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[84] Conversations with Bill Reed of Natural Logic, Tom Paladino of Paladino & Company, and many others, and internal experience at KEMA-Xenergy.

[85] The Mayor's Budget Message available at www.sjmayor.org/memos/bmessage2001.html appropriates $491,000 for the $7.9 million project to cover LEED certification.

payback horizons, especially since facilities are typically owned and operated for many years, if not decades. However, in many municipalities, the operations and capital budgets do not "communicate," and typically funds cannot be transferred between the two. Thus, operational savings do not compensate for additional investments up front.

Library projects funded through bond measures or equivalent means, which constitute a significant percentage of total new construction library projects, have typically established project budgets without the inclusion of green building measures or LEED certification. As a result, if green goals or requirements are introduced to a project after the bond is passed and a budget based on program requirements is already set, then project teams typically claim that the project budget does not exist to incorporate green measures (at least to the level of LEED certification). Thus, green elements become an "add-on" and do not get implemented to their maximum potential, or they create a need to request more money for implementation, regardless of the validity of this claim.

In addition, many budgets are structured with little or no flexibility. For example, bond approved budgets for a library program might have been established on a line-item basis, allocating certain amounts per project, over a phased implementation schedule. Under this scenario, the bond program typically will not allow the flexibility to use some of the future bond funds to pay for any short-term additional cost of green measures that could have been imposed after the bond was passed. This is the case even if project teams can demonstrate that investing in green measures in the earlier projects at additional capital costs will ultimately save capital costs in buildings that will be coming on line in the future.

Budget restrictions are one of the primary reasons that library projects typically do not attempt to achieve LEED certification above the Certified level. Most of the registered projects under construction, or near completion, are striving for this level because most projects can achieve this level with little or no increased capital cost.

MANAGING COSTS

This section presents strategies for designing and building green public libraries while lowering the capital cost to the greatest extent possible. In addition to the General Strategies presented earlier, library projects provide some unique opportunities for managing LEED costs.

Take advantage of the inherent synergies between LEED and libraries

Site selection / transit

Due to the mission and purpose of libraries and their municipal nature, it is imperative that they are widely accessible to the public. As a result, libraries typically promote transportation alternatives. New facilities are highly accessible by disabled and senior citizens via train, bus, van, and with ramps and seamless entries. It is also commonplace for libraries to provide secure bicycle storage for building occupants and visitors. These strategies are consistent with the intent of LEED to reduce pollution and land development impacts from automobile use. However, LEED carries these concepts a little further.

To earn LEED points, library projects must include both bicycle racks and shower facilities that serve 5% or more of regular building occupants. Though many libraries provide bike racks as standard practice, few provide shower facilities. Though most library patrons are not likely to

need showers, employees who cycle to work would benefit from them. Some bicycling advocates believe that including showers can motivate some of the building users who do not currently bike to work to do so. Because library staffs tend to be small for the building size, it would be relatively cost effective to install a shower or two to meet the LEED requirement, especially if planned early in the project. While showers are only required for a percentage of the building staff to meet the LEED requirements, safe and secure bicycle storage is a relatively low cost item and should be planned for both patrons and employees.

Libraries are typically located within a quarter of a mile of two or more bus lines, or within a half a mile of a commuter rail, light rail, or subway station. As a result, libraries typically earn the LEED point for public transportation access at no cost. Though libraries are required to provide ample parking, the more alternative transportation opportunities a building provides, the more accessible it is and the fewer parking spaces it requires.

The Carver Public Library project in Austin, Texas is an addition and renovation to an existing library facility. The siting decisions were made years ago. However, since the value of improved access had been considered in the original planning phases of the project, the project was able to automatically achieve the LEED mass transit point and the bicycle point with addition of a shower. In addition, the team added an electric car charging station to receive another point.

Indoor Environmental Quality

As places for people to gather, read and learn, libraries inherently have requirements for healthy indoor environments. In addition, good library design is already consistent with the intent of LEED to promote improved indoor environmental quality (IEQ). As a result, libraries are naturally positioned to benefit from most of the LEED IEQ measures.

Libraries require carefully controlled interior environments to preserve collection materials and to provide a comfortable setting for research and teaching. Interior air quality, temperature, and humidity levels must be held within narrowly specified ranges. These issues and air quality are also critical to providing a comfortable indoor environment for library users and staff. Utilizing low-emitting carpet, interior paints, and construction sealants and adhesives can be accomplished consistently with little to no cost premium. Investing in effective thermal comfort and ventilation effectiveness can contribute significantly to creating a functional, desirable, and healthy library environment, while supporting LEED goals. When considering potential cost implications associated with these measures, it is important to recognize which measures are consistent with the library's fundamental mission and purpose and thus which measures should not be singled out as "green add-ons" when they are presented during the LEED goal setting process.

Materials

Durable and easily maintainable materials are inherently sustainable over the long term. If high quality, durable finishes are budgeted into a project from the beginning, then many recycled content and non-toxic alternatives can be substituted with little to no cost impact. Often library projects are budgeted to include high quality materials intended to last the life of the building. This gives architects increased flexibility to substitute long-lasting green materials into the project. The most cost-effective material selection processes will focus on products with long-term durability, healthy and simple maintenance practices, and low-emitting constituents. To achieve higher levels of sustainability and additional LEED points, these materials should also contain recycled or rapidly renewable material and be procured from local sources to the greatest extent possible. The more synergistic a material is amongst these sustainability categories (i.e.,

recycled content, regionally sourced or extracted, rapidly renewable, etc.), the more cost effective it will be for earning multiple LEED points.

In urban projects, designers should select materials that will withstand a variety of uses by a wide range of populations. The team should consider the impact of the homeless, children and vandals. Will the bathroom sinks be used to take baths? Will floor coverings need to withstand excrement and urine? Is a high level of graffiti expected? If so, durability and maintenance requirements will be heightened in these projects and will likely take priority over other green measures. For example, in the new Seattle Central Library, the team opted not to use low-emitting paints and coatings because of concern about their ability to meet specialized cleaning and durability requirements. In this case, they selected a range of specialty coatings instead. Since these coatings will last so much longer than low-emitting paints in this application, they are probably the greenest option.

Maximize the use of carefully planned daylighting

A typical public library is housed in a one- or two-story building with large, open interior spaces. As a result, there is great opportunity to provide general lighting primarily with daylight. Designed well, daylighting significantly reduces the energy cost to libraries. It provides a connection to the outdoors for the occupants, and incrementally reduces the impact of electric power generation on the environment at large.

Carefully planned general daylighting is consistent with library program priorities. Regardless of LEED, library projects strive for well-lit reading spaces where direct light will not harm the books, create eyestrain, or cause glare on computer screens. These criteria are consistent with the preferred daylighting design strategies promoted in LEED. In addition, daylighting strategies can be used to achieve multiple LEED credits through a single design approach, thus maximizing the cost-effectiveness of incorporating green design and earning LEED points. Appropriate design can earn LEED points for introducing daylight to building occupants, providing a connection between indoor and outdoor spaces, and optimizing energy performance.

In terms of specific daylighting strategies, LEED can be leveraged to support the inclusion of daylighting measures such as appropriate windows, clerestories, and skylights. In one San José library project, the proposed skylights were nearly removed through the value engineering process as a cost cutting measure. Fortunately, the architect successfully argued to retain the skylights because they would help to achieve the LEED daylighting credits and assist with optimizing energy performance.

The West Valley Library in San José was late in construction documents when they received a mandate from the city to achieve a LEED rating. Because of the timing, the design had already lost opportunities for the inclusion of a number of measures that would have added little or no cost. Because they had already designed the library to have daylighting and views, however, they had two LEED points without any additional work. While some minor changes can be made late in a project, daylighting is not something that could have been easily inserted at the time the LEED effort began. Because the team had already designed for even, natural, indirect lighting, they were able to achieve points for both daylighting and views.

Keep it simple: less can be more

Designing a simple building is one of the easiest ways to control costs. For example, the design team on the Crowfoot Public Library in Calgary, Alberta was actually able to deliver a larger building than originally planned because of the straightforward, simple floor plan. The architect cited the team's ability to simplify the project as the most important way to control the costs. It is important to understand that simplicity does not necessarily mean boring; "simple" strategies

such as well thought out detailing and material use and clerestory daylighting lend to the overall appeal of the project.

Some green buildings benefit from minimizing finishes – such as substituting sealed concrete for carpet or higher end flooring, exposing the building structure where possible. While libraries can use structure as finish in some cases, careful attention should also be paid to acoustics. The structural decking in the Crowfoot Public Library is exposed, allowing for an effective indirect lighting design. To ensure sound control, the architect specified an acoustical metal decking with insulation inside the flutes. High-recycled content carpeting was also used throughout the stacks, further minimizing noise problems. When properly designed, the use of structure as finish can help minimize material costs in libraries.

The Crowfoot Public Library was provided the same dollar per square foot budget that every other Calgary library receives. However, from the beginning, the team knew that their charge was a LEED Silver project. Not only did the team deliver a project without additional hard costs, they designed a building over 10% larger than the original base budget building. Because the building had a simple plan and a simple structural system, the team was able to add on an additional bay without going over budget. The simpler mechanical design resulted in a decreased mechanical budget largely due to more efficient heating and cooling systems. The design team opted to eliminate most of the ceilings, allowing for a decrease in the materials budget and an effective indirect lighting system. Finally, the integrated design process was the key to keeping the costs down. Eliminating unnecessary frills, the architects were able to create an interesting, stimulating design, while achieving their LEED goals.

Engage the owner/tenant

In some ways, LEED is easier to apply to libraries than it is for many other building types. Since LEED was initially developed for offices, which often have separate building owners and tenants, office building projects can encounter challenges when the owner and the tenants have conflicting goals and interests. For example, if tenant improvements are not a component of the basic project, then they will not necessarily be consistent with the sustainability goals of the core building (or vice versa).

Since the owner is the tenant in most public library projects, the decision-making process can be streamlined throughout planning and design. Just as owner representatives should be included in project planning and design discussions, tenant representatives should be allowed to provide insight into building use patterns, operations issues, and maintenance practices. When the tenants are engaged in materials selection and equipment preferences early in the planning and design process, potential roadblocks to implementation of alternative methods can be minimized and future operations and maintenance problems avoided.

Size mechanical systems based on actual demand, not past inadequacies

The nature of libraries has changed in the last 20 years. They now house substantially more computers and other electronic equipment. In existing libraries, task lighting has been added to assist with work near the new equipment, often without reducing ambient lighting. This redundancy, and the increased number of users in libraries, means that mechanical systems operate at maximum design capacities, often failing to perform adequately. As a result, staff and owners request much larger HVAC systems when new facilities are designed, typically resulting in oversized systems.

Mechanical design in new libraries should respond to the actual demand and anticipated growth of the facility. The design should not react to and attempt to overcompensate for the inadequacies

of older mechanical systems. Increased energy efficiency should allow for smaller and more efficient systems than in conventional construction. Since LEED rewards projects for optimizing energy performance, downsizing and/or eliminating mechanical systems can contribute significantly to achieving LEED goals and help to reduce capital costs. Some owners might be nervous about downsizing (or "right sizing") if their older facilities are having mechanical trouble. However, a mechanical engineer experienced with integrated design strategies should be able to understand the concerns of the users and address the library's actual physical requirements. Of course, appropriate capacity should be built into the system such that it can respond to future needs. However, the more closely the library can anticipate future uses, the more easily and cost effectively this can be accomplished.

Keep up with library trends and design for flexible uses

Municipal library programs often require flexibility of use. For example, an individual library could call for an information resource center that will also house multiple public functions during extended hours, such as community meetings, movies, storytelling, computer classes for seniors, and author appearances. This flexibility of use requires adequate lighting and mechanical infrastructure to accommodate a broad range of potential uses and activities. Materials used will have to withstand heavy usage and be easily maintainable.

Though flexibility is important for any green building, designers should avoid over-design, redundancy of systems, and oversimplified solutions. This can be an issue with regard to lighting. For example, requirements for a room to have the capability of going totally black could inhibit incorporation of daylighting strategies. However, instead of eliminating fenestration all together, windows, clerestories, or skylights should be installed with blackout shades where appropriate. The use of daylighting and efficient electric lighting, though potentially adding cost up front, can save money in energy bills over time and will make the rooms much more enjoyable. The better the owner and architect are able to understand and plan for future uses, the longer each space will remain functional, and the more cost effective the design decisions will be for the life of the building.

Libraries often contain rooms with vastly changing occupancy levels, and therefore are well suited for carbon dioxide (CO_2) sensors. A community gathering space, for example, may shift from zero to 100 people in just a few minutes as a class begins. The carbon dioxide sensor is a cost effective way of ensuring proper circulation in those spaces. This has the dual effect of making the room more comfortable for its occupants and saving energy when the room is not in use. In addition, LEED rewards projects that provide capacity for indoor air quality monitoring through CO_2 sensors.

Select the appropriate level of flexibility

Designers should determine the level of flexibility required for any library facility. Flexibility issues include adaptability, adjustability, and expandability. An easily adaptable library would include a basic configuration that could accommodate a wide range of uses with only a minimal amount of change to furniture and book stacks. An easily adjustable library would include components that were moveable depending on changing research needs with only basic labor requirements, no heavy construction work, and no impact on adjoining spaces. Expandable libraries allow for the easy reshaping of modular components to create or add new spaces or functions.

Design teams should address these issues early with the owner because of the potential impact on building programming, services, and budgeting. Though a small amount of built-in flexibility

may not result in an additional cost, most features that provide flexibility will have moderately higher up-front costs. These changes will, however, reduce retrofit costs and associated material waste, and may even extend the usable life of the building.

Thomas Hacker Architects originally intended the Hillsdale Branch Library in Multnomah County, Oregon to have exposed structural wood decking made of clear vertical grain fir. However, Forest Stewardship Council (FSC) certified sustainable lumber was only available in shorter, more narrow dimensions. As a result, the architects changed their design aesthetic to match their environmental values, moving from a clear lumber to a tight knot lumber. In making this transition, procurement of FSC certified lumber was actually cheaper than the conventional equivalent.

Find a dedicated contractor

Even a conventional design-bid-build process can yield successful results. In the case of the Southern York County Library in Shrewsbury, Pennsylvania, the project team was almost all new to the LEED process. Despite this lack of experience, the contractor was very interested in learning about green building and willing to go through a learning curve on this project. Thus, by embracing the notion of incorporating LEED, the contractor was able to deliver a successful, cost-effective project. In addition, as different members of a project team participate in more and more LEED rated buildings, the more comfortable they will be in using different design and construction processes.

Neither the architect nor the engineer had much experience with LEED on the Southern York County Library project. Funded through grant money from a local non-profit, a sustainability consultant was able to work with the team with limited success. The project went out to bid without all of the proper LEED documentation, and the selection process was based on a low-bid format, which can be difficult to work with on LEED projects. Fortunately, the low bidder was also very motivated to learn about green building. Due to the required documentation constraints and the rigid structure of the design-bid-build process, the project was not set up for success to achieve a LEED rating. However, an enthusiastic contractor willing to put in some extra effort, made all the difference.

Use local code language to support green goals

Local codes can provide language that directly or indirectly supports green building goals, including specific LEED credits. In Sarasota, Florida and Seattle, Washington, library projects found that they were part-way or very close to reaching water efficient landscaping credits because of locally imposed ordinances dictating rainwater storage. In Seattle, the city requires projects of a certain size to construct concrete holding tanks so that the projects will release stormwater more slowly over time. The addition of a large storage tank for irrigation water at the new Seattle Central Library did cost a premium, but the added cost is less than the project would have incurred had there been no local requirements. In Sarasota, the North County Library was required to store rainwater, regardless of LEED. In most cases, local codes will not work as directly toward LEED credits as in this example, however many progressive codes, such as California's relatively stringent Title-24 energy code, or Seattle's rainwater storage requirements may provide the impetus to push beyond conventional standards.

Address municipal standards (if necessary, work to change them)

Program requirements: lighting

In some cases, program requirements may be at odds with sustainable design goals. For example, in the majority of city library projects, library staff does not allow task lighting in public areas because of vandalism and annoying misuse. Without task lighting, a typical target of 50 foot-candles for all work planes requires greater energy use, which is inconsistent with the LEED goals of optimizing energy performance. In addition, requiring uniform levels for all task areas including computer stations is inconsistent with Illuminating Engineering Society of North America (IESNA) guidelines and is inherently inefficient. Municipal staff may also require specific vertical surface light levels, for example 27 foot-candles at 30 inches on the stacks, even though accepted practice is to provide 15 to 18 foot-candles. Greater lighting design flexibility is necessary to achieve LEED goals of optimizing energy performance cost effectively.

Modifying lighting designs by reducing ambient light and including task lighting and indirect lighting to reduce electricity usage is possible. The Southern York County Library reduced its ambient light by 50%, eliminating 40% of the light fixtures. The Hillsdale Branch Library is installing task lighting at study carrels and in staff workrooms. In Calgary, an electrical engineer proved, through a light simulation, that the project's indirect lighting system worked more effectively than the conventional lighting designs. The team was able to design lower light levels, even though the light coverage low on the stacks was an improvement over the standard. As a result, the city recognized the benefits of the design and was willing to change the standard.

In Calgary, municipal standards for libraries work both for and against lighting schemes. The typical shelving height is five and a half feet tall. A lower product than allowed in many libraries, this height allows for increased visibility, air circulation and daylighting opportunities. The standards for electric lighting, on the other hand, were not ideal for a green project. The City of Calgary requires high foot-candle levels at the base of the stacks and throughout library buildings. Despite these conflicting code requirements, electrical engineers in the Crowfoot Public Library designed an indirect lighting system to reflect off the exposed ceiling. They used a light simulation to prove to the city that not only did the project require fewer total foot-candles, it also had better light coverage at the bottom of the stacks than the standard lighting scheme did. The city allowed the team to bypass the standard, reducing the lighting power demand significantly.

Program requirements: parking

In some cases the building owner might want to maximize parking on the site, whereas LEED rewards projects for minimizing parking and promoting alternative transportation. Typical municipal library projects in Los Angeles have over 1.5 times as many parking spaces as required by local code. Even a LEED registered project, Lakeview Terrace Branch Library, is designed for 29 spaces although only 21 are required by code.

Parking spaces are not cheap, especially if they are structured. By building libraries in close proximity to transit and in bicycle- and pedestrian-friendly neighborhoods, the need for parking is reduced, creating significant cost savings. This can save space on the site and help to create healthy habits in library users.[86] Additional opportunities to reduce parking area may be possible if the library is adjacent to other facilities with ample parking. Valuable space and money can be

[86] A 2003 study of 200,000 people across the U.S. led by Reid Ewing at the University of Maryland's National Center for Smart Growth found that people who live in dense urban areas weigh an average of six pounds less and are less likely to have heart attacks than those in suburban areas because they walk more.

saved by seeking out ways to share parking, either on a regular basis or for special events. For example, in Austin, the Carver Library renovation and addition is under construction on the same site as a museum and theater and is adjacent to a school. The facilities have agreed to share parking, especially for evening and weekend events when the school is less likely to need many spaces. Creative parking plans such as this can minimize the cost of site development and stretch scarce municipal resources.

Program requirements: shelving

Shelving, a key component in every library, is often determined by municipal standards. Unfortunately, imposed standards may be inconsistent with green goals. If the imposed standards are not environmentally friendly, project architects should work with the municipality to reach an agreeable alternative. Green options are available for shelving that can help earn LEED points.

A variety of alternative shelving materials exist, including metal, wood, MDF with no added formaldehyde and wheat board. For metal shelving, most alternatives will have recycled content. Wood shelving can be made of FSC certified wood, though this option will not save money and probably will add cost. Projects can also seek additional options in rapidly renewable materials. For example, in the Southern York County Library, the project team convinced a shelving manufacturer to use wheat board on their standard product line.

In addition to making informed decisions for shelving based on material content, project teams can also consider the indoor air quality impacts of the shelving. To promote healthier indoor environments, teams should strive to use products with no added urea-formaldehyde—either agrifiber boards or medium density fiberboard (MDF) without added formaldehyde—for any shelving or casework with composite wood. Custom casework and shelving manufacturers will often bid competitively with larger operations for such products, and they might be more willing to work with different materials.

Make sure the municipal building process is on board

As municipal buildings, libraries might have design and construction processes predetermined by their owners. While the balance between architect, owner, and contractor can be a difficult one in any project, the inclusion of LEED requirements imposes additional challenges. Ideally, everyone involved with the project should be fully on board with green building and have a clear idea of the implications of achieving a LEED rating.

Green building has widely appealing objectives, and public officials are often willing to listen to sound arguments for modifying or allowing variances to both codes and design standards. The City of Chicago uses prototypes as standard practice for a number of different building types, and because of the success of LEED, the city is now considering changing some of these standards to be more compatible with LEED requirements.

The City of Austin represents an architectural environment that has already shifted toward green building practices. Though a number of library standards exist in Austin, they are consistent with LEED measures, or at least do not act as barriers to implementation of green goals. This shift occurred over time as projects in the city experimented with more and more green measures. By the time LEED appeared on the scene, the city was already familiar with green concepts and had already begun to modify standards to be “green-friendly,” thus enabling successful green projects, instead of creating barriers to success.

Similarly, the green building process for libraries will go considerably more smoothly if municipal standards are consistent green objectives. Most standards are currently not as

progressive as Austin's or those of other cities that have embraced LEED (such as Seattle and Portland); these municipalities can be viewed as leaders.

Leverage external funding sources

Green library projects in some regions may be eligible for grant money. Local philanthropic organizations and government agencies are now giving out green building grants in amounts ranging from $5,000 to more than $100,000. The Southern York County Library received a $20,000 grant from The York Foundation to assist with implementation of green measures. New construction and major retrofits of public buildings in Alameda County are eligible for similar grants from the Alameda County Waste Management Authority for achieving LEED certification. Grants typically fund services such as design assistance, charrette facilitation, and LEED documentation costs or materials costs.

RESOURCES

Dean, Edward, AIA. *Energy Management Strategies in Public Libraries*. ISBN 1-890449-19-9. Monrovia, CA: Navigator Press, 2002. Available for purchase at: www2.njstatelib.org/njlib/construction/consenrg.htm

Syphers, Geof and Darren Bouton. *Capital Cost Analysis for Building Two Green Libraries in San José*. Report for the City of San José, San José, CA, 2001.

U.S. Green Building Council, www.usgbc.org

Weiner, James, Dennis Bottom and Lynn Boyden. *The LEED Rating System as a Guide for Building Design: A Comparative Analysis of Two LEED-Evaluated Public Libraries*. For presentation at the American Solar Energy Society Conference, Washington, D.C., April 23-25, 2001.

Weiner, James, Lynn Boyden and Bill Holland. *Mainstreaming Environmentally Responsible Design with Public Library Building Projects: The LEED Rating System and the 1998 Los Angeles Library Bond Construction Program*. For presentation at the American Solar Energy Society Conference, Madison, WI, June 19-21, 2000.

Research Laboratories

CONTEXT

The environment necessary in research laboratories to safely handle dangerous and delicate experiments is expensive to build and operate. Unlike with many other building types, lab designers have long been attentive to the health impacts of chemical use, ventilation and emergency situations, and to the high energy and water use in these facilities. Other issues, however, such as daylighting and material off-gassing, have been historically neglected. As heavy resource users, these buildings also have ample room to lessen their environmental impact.

Fortunately, there are many ways to manage costs while promoting green building objectives. The most important of these strategies address standardization and simplicity, setting realistic design criteria for the degree and precision of environmental control and energy efficient air filtration, exhaust and heat recovery. This chapter provides specific cost management strategies for research laboratories that build on the guidelines presented in the General Strategies section.

Laboratories: LEED and Labs 21

Throughout this report the Labs21 Environmental Performance Criteria (Labs21 EPC) and LEED Rating System are referred to synonymously even though they are different programs. Labs21 EPC is based on LEED with only minor changes to each section except *Energy & Atmosphere*, which reflects the vastly larger energy demand in laboratories.[87] The U.S. Green Building Council (USGBC) is exploring the development of a LEED Application Guide for Laboratories that would likely use part or all of the Labs21 EPC.[88] As of October 2003, it was not possible to certify a project under the Labs21 EPC program. Current laboratory projects are using LEED 2.1 for obtaining certification but they are largely using the Labs21 EPC as a general design guide.

There are several key differences between LEED and Labs21 EPC.

[87] Research laboratories often use more than five times the energy of a comparably sized office building, according to the *Laboratories for the 21st Century Energy Analysis*, by Enermodal Engineering and NRL, DOE/GO-102003-1694, April 2003.

[88] Conversations with Dale Sartor of LBNL and presentations by USGBC faculty (e.g., Kath Williams at Energy 2002, Palm Springs in June 2002).

The laboratory-specific prerequisites and credits found in the EPC but not in LEED include:[89]

Sustainable sites	Use of physical and computational modeling to assess and reduce impact of air effluents.
	Elimination of water effluents into sanitary sewer.
Water efficiency	Eliminating use of potable water for open loop water systems for laboratory equipment.
	Documenting and reducing process water use and process waste water generation.
Energy and Atmosphere	Selection of minimum ventilation rate to achieve optimal balance between user needs, health/safety protection and energy consumption.
	Reduction of energy consumption through the use of energy efficient laboratory systems and equipment.
	Use of efficient on-site energy generation systems to reduce source energy use.
	Right-sizing mechanical equipment by improving estimates of heat gain from laboratory equipment.
Materials and Resources	Reduction and management of hazardous material stream.
	Chemical resource management plan to reduce and manage laboratory chemical supplies.
Indoor Environmental Quality	Use of computational fluid dynamics to optimize indoor airflow for contaminant containment.
	Conducting fume hood commissioning as per ASHRAE standard 110.
	Use of fail-safe and self-identifying alarm systems.

Labs21 EPC also introduces a new prerequisite requiring all projects to address certain ventilation issues. The intent is to "determine minimum ventilation requirements in laboratories based on user needs, health/safety protection and energy consumption." The prerequisite includes requirements to:

- "Determine the necessary fresh air ventilation rate and number of fume hoods and other exhaust devices based on applicable codes and the planned use of the laboratory over the next five years;
- Consider exhaust alternatives such as instrument exhausts and ventilated storage cabinets with very low flow ventilation and good ergonomic accessibility;
- Develop a workable fume hood sash management plan including: a) informational placards for hoods and b) awareness and use training. The Sash Management Plan should be incorporated in the Chemical Hygiene Plan for the laboratory."

In discussions with lab designers, these practices were found to be commonplace but not universal. The cost impact for projects that do not currently meet these standards should be favorable from a lifecycle perspective and result in only a moderate increase in design and implementation time.

[89] Table is reprinted from the Lawrence Berkeley National Laboratory's Environmental Energy Technologies Division EETD Newsletter, Summer 2002, http://eetd.lbl.gov/newsletter/nl11/lab21.html.

The Labs21 EPC recommendation for installation of on-site renewable energy is to reduce LEED percentage requirements such that providing 2% of the building's total energy use would earn one point, 5% would earn two points, and 10% would earn three points. This recommended modification is in response to the much higher energy usage in laboratories, as compared to traditional commercial office buildings, for which the LEED rating system was initially developed.

Cost Issues

Research laboratories are expensive to build, costing two to ten times as much per square foot as an ordinary office building.[90]

As of October 2003, there were six LEED-certified laboratory buildings and 61 more registered for future certification.[91] Using conventional budgets and design practices, typical research laboratories are likely to achieve default scores in the 22-to-32-point range because of the following factors:

- High level of equipment and controls commissioning is common.
- Many opportunities for saving energy relative to the high base case (e.g., energy recovery with heat pipes or enthalpy wheels, ventilation rate reduction, or demand ventilation controls). Because the amount of energy laboratories typically use is so high, basic energy efficiency strategies can be very cost effective.
- Use of expensive metal materials that are likely to contain high recycled content.
- Base case finishes are relatively expensive, so substitution of premium low-emission and recycled-content materials will not add significant cost.

San Mateo County hired HOK to design a green forensics lab, but the team did not consider a LEED rating until late in the process. The county agreed to certify the building when, near the end of construction documents, the architects realized that they could easily achieve a LEED Silver rating with the existing design. LEED documentation requirements, however, were not integrated into either the building specifications or the contract with Turner Construction. Had this been done in advance, the team would have saved a great deal of time and money in the documentation process. Instead, much of the documentation work had to be completed after the fact, and continued on for months after the project was completed. This late decision shows not only the importance of timely decision-making, but also that achieving a LEED rating, though potentially incurring additional soft costs, does not necessarily add any construction costs.

Design Cost Factors

Special tasks that are only commonly done for laboratories, such as water-polisher effectiveness calculations and fume hood airflow modeling can impose higher design costs on lab projects. These costs can be recovered through:

- Reduced maintenance, churn, and renovation costs;
- Reduced utilities (electricity, gas, water);
- Improved health and productivity of occupants;
- Lower debt service;

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[90] Labs21. *Environmental Performance Criteria*, Available at: www.epa.gov/labs21century.

[91] USGBC, Registered Projects. See: www.usgbc.org/LEED/Project/project_list_registered.asp.

- Decreased liability;
- Longer life of building materials;
- More desirable workplace–worker retention, tenant occupancy.

Though significant benefits can be achieved through reduced operating costs, these gains often require additional up-front investment. In general, the design-related cost factors such as energy, safety, and complexity have been well addressed in industry guides and journals, more so than the hard project costs have been.

MANAGING COSTS

This section presents strategies for increasing the efficiency of project managers and design teams attempting to build green laboratories while lowering the capital cost to the greatest extent practical.

Be aware of infill challenges

Infill projects, though environmentally preferable, can be a challenge for some laboratory projects, and it is important for senior decision makers to understand the broad issues. Depending on the type and intensity of research, some laboratories are likely to bring odor, noise or light pollution into a community. Though they are required to treat air and water discharges, laboratories may still emit unacceptable levels of pollution into the environment or at least be perceived as doing so. Laboratories may create a real or perceived threat of hazardous materials, terror threats, explosions or biological contaminants, depending on the research conducted at the facility. With large facilities, it is possible that the high resource use can be a burden on local water, sewage and energy supply. Though the resource use and other disadvantages may be offset by the creation of new jobs, many residents and businesses are unlikely to want a lab to be located nearby.

Despite these challenges, some urban infill sites are appropriate for laboratories—areas like former industrial sites or large parcels being concurrently developed with multiple uses. When community issues are addressed appropriately, most laboratories can be developed alongside other building types, but because of these general difficulties, infill is not emphasized as a cost-saving green measure.

LEED point person should have laboratory experience

Laboratories are fundamentally different from office buildings and although nearly all laboratory buildings have offices in them, it is the laboratory portion of the building that should dictate the experience of the LEED point person. The laboratory and lab support portion of projects typically have more complicated energy, water, and resource issues, so the point person should have a good understanding of laboratory design to be able to balance the lab portion of the building with the non-lab portion, and creatively find synergies and tradeoffs between the two.

Maximize synergies between lab and non-lab materials and systems

Maximizing synergies between materials and systems is crucial in every building type, but differences between lab and non-lab parts of laboratory facilities can vastly increase the range of

possibilities and potentially lead to a capital cost savings. The elimination of drop ceilings in laboratories, for example, might help to offset the costs of rapidly renewable materials in offices; the high floor-to-floor height required by laboratories might improve daylighting in office and other non-lab spaces; use of a simple and inexpensive construction system might allow room in the budget for an efficient mechanical system. Avoid thinking of each component in isolation; a whole-building approach to laboratory buildings is one of the most effective ways to keep costs reasonable.

Mechanical system design can follow a similar approach. Office air can be used for makeup air in some laboratories. Waste heat from server rooms might help to condition office or lab spaces. When different space types are well balanced, these strategies can offer significant energy savings, potentially allowing project teams to reduce the size of some equipment.

Designers of the San Mateo County Forensics Lab underwent intense materials and systems research in preparation for the project. For example, covering the entire roof with photovoltaics allowed the team to specify an inexpensive roofing system; not only do the photovoltaics hide the cheap material from view, it also shelters it from the sun, lengthening its life. In the laboratories, the designer eliminated conventional drop ceilings, enhancing daylighting and giving the space a larger feel. The team originally intended to use FSC-certified wood casework but found it to be prohibitively expensive. Instead, they opted for wood from a non-FSC-managed forest in the laboratories and a wheat board in the non-lab spaces. Through synergies and tradeoffs like these, the architectural component of the project was brought in at standard costs.

Energy Use

Laboratories designed to meet LEED Silver requirements should strive to achieve at least a 20% reduction in energy use from the Title-24 code allowance. Table 8 lists the four laboratories that have achieved LEED certification to date, with their final calculated energy savings. Only the Bren Hall at the Donald Bren School of Environmental Science and Management at UC Santa Barbara is located in California and is therefore the only facility to use Title-24 to set its energy budget. Because Title-24 is more stringent that ASHRAE 90.1, it is estimated that the projects listed in the table would beat the California energy code by between 24% and 30%.

Table 8. Energy Savings Performance for LEED™ Certified Laboratories

LEED Certified Lab	LEED Rating	Energy Savings Performance
Nidus Center St. Louis, Missouri	Silver	33% less than ASHRAE 90.1 1989
Pharmacia Building Q Skokie, Illinois	Gold	38% less than ASHRAE 90.1 1989
Donald Bren School of Environmental Management Santa Barbara, California	Platinum	30% less than 1998 T24[92]
Emory Whitehead Biomedical Research Building Atlanta, Georgia	Silver	30% less than ASHRAE 90.1 1999

In California, Gold or Platinum laboratories would likely need to beat Title-24 by upwards of 30%, install some amount of renewable energy, and for Labs21, provide a very high degree of safety for the occupants and include provisions to treat air and water effluent.

Reduce energy use: whole building approach

Laboratories use considerably more energy than conventional office buildings, so it is no surprise that one of the most substantial lab-specific challenges is related to the mechanical system. The first step should be to reduce the amount of energy the building requires; the second is to make the systems as efficient as possible.

Although most energy use is determined by laboratory HVAC functions, other building energy uses are not insignificant and should therefore be addressed. Major energy savings can be recovered by integrating daylighting strategies with the use of efficient light fixtures. Use of appropriate glazing, insulation, and other conventional strategies remains important in a building's energy consumption. Energy models can help determine the most effective materials, fenestration, orientation, and other practices.

Code classifications based on occupancy and hazardous materials can also affect HVAC requirements and energy use; the design team should discuss these requirements with the owner early in the programming process. It is important to understand these classifications early in the process to minimize changes to the mechanical system later on.

On Sigma Aldrich's Life Sciences and High Technology Building in St. Louis, Missouri, good daylighting pays off

LEED attributes are just like all the other attributes, to be grown or cut together.

A current laboratory project with HOK and Flad for a private client incorporates sustainability into the entire design. When the client requested substantial cost cuts due to external financial pressure, they asked for the green measures to be cut. On researching the possibilities, the team found that many of the integrated green elements were not separable from rest of the design and simply cutting them would end up costing the project *more* money. A whole-building analysis was used to find the cost savings instead.

[92] Note that the Title 24 Energy Code is evolving and is updated periodically, such that a building that exceeded 1998 Title 24 energy efficiency requirements by 30% might exceed 2001 requirements by some other lesser amount.

beyond reduced electricity bills. From the beginning of the project onward, the owner established the goal of attracting and retaining top-notch employees—a challenging feat when many qualified employees are attracted to higher profile cities. The extensive daylighting in laboratories, offices and common spaces, as well as healthy building materials and appropriate ventilation strategies, all make the building an enjoyable and exciting place to work.

Reduce energy use: air exchange rates and fume hoods

The two largest determinants in a building's energy requirements are usually the fume hoods—their size, quantity, style or design, and exhaust connections—and room air change rates. These components affect not only the mechanical system, but also potentially the plenum height and shaft sizes and locations, variables that can have a substantial impact on building design and cost.

Architects, engineers, and building users should work together to determine the air exchange rates appropriate to the use of the building, taking future uses into consideration. The design team should take a close look at special needs for biohazard level requirements, unusual pressurizations, and larger-than-normal hood or other equipment use. Although rightsizing is an important concept for all lab spaces, it is especially relevant for these intensive conditions. Teams should consider options for use of a "mini-environment," or locally isolated environments like a glove box, that will accommodate special environments in a more efficient way. In clean room conditions, the level of pressurization is another factor affecting energy efficiency. Specific ventilation requirements for all lab spaces should be determined early in the project and should help to shape system design.

In addition, design teams should work towards achieving the minimum necessary face velocities on fume hoods; often these are vastly oversized. A wide range of research is available on appropriate face velocities, and a variety of different hood designs are available to maximize efficiency. The major energy use by fume hoods does not come directly from their operation, but rather from the conditioning of the air that they remove from the space. By minimizing—or right-sizing—the air that flows through hoods to the exhaust, less conditioned air needs to be ducted into the space. This can contribute not only to energy savings down the road, but also to a lower capital cost through reduced air handler and duct sizing. Ideally, computational fluid dynamics modeling should be used to determine that the air flow in the laboratory is healthy for the occupants and appropriate for the research. Despite proven efficiencies of low flow hoods, current Cal/OSHA regulations prohibit the installation of fume hoods in California with face velocities of less than 100 feet per minute. A variance to this standard would have to be granted for "low-flow," high efficiency fume hoods to be installed in laboratory projects.[93]

In the Magruder Hall renovation and addition at Truman State University in Missouri, there is a stop on each fume hood so it can only be raised to the halfway point. This reduces the air flow and the size of the air handler. An alarm sounds if the sash is raised beyond that point, which can be turned off with a key. The value engineering estimate listed a reduction in air flow of 5000 cfm, for about $20,000 in reduced air-handler costs. The change was made on 126 hoods with a first-cost savings of $150 per hood. The diversity factor was fairly high at 80% because of high hood use during class time and to accommodate the addition of hoods in the future. Had the diversity factor been reduced through other measures, the cost savings would have been greater.

[93] State of California. California Code of Regulations. Title 8. Subchapter 7. General Industry Safety Orders Group 16. Control of Hazardous Substances. Article 107. Dusts, Fumes, Mists, Vapors and Gases. Section 5154.1. Available at: www.dir.ca.gov/title8/5154%5F1.html.

Specify durable and recycled content materials

The primary considerations for material selection in laboratories are safety, chemical resistance, and durability. Expectations should be discussed with project decision makers and laboratory users early and throughout the project to ensure that the design is consistent with their particular needs. Many organizations will have casework or material standards that should be addressed early to determine if there are environmentally preferable alternatives. The materials questions that the design team should address include wood versus metal casework, bench-top color and material, flooring and wall chemical resistance properties, wash-down requirements, and flexible, adaptable, and/or modular casework.

Materials inside laboratory spaces can take a substantial amount of abuse. Flooring, bench tops and walls should all have appropriate finishes and other protections to ensure durability. Walls in hallways and other circulation spaces should have some type of preventative bumper device to protect the walls from contact with carts, dollies and large pieces of equipment. Service elevators, hallways and appropriate intersections should be sized for adequate transportation of the facilities' largest hoods or other equipment.

Options for material selection of the laboratory components of buildings are typically more limited than in conventional commercial construction. Because fewer material suppliers offer laboratory-specific products such as casework or epoxy flooring, these materials are less likely to be available locally. Because of the high level of chemical resistance required, few lab-specific materials are rapidly renewable. The ability and the cost required to achieve both the local and rapidly renewable credits will depend on product availability and the percentage of the construction materials that are laboratory specific.

Laboratory equipment can potentially include recycled content at no additional cost. Steel casework typically has both post-consumer and post-industrial recycled content; the quantity varies depending upon the manufacturer, but is often around 25%. Stainless steel, used in food laboratories, is likely to have a high level of recycled content. Because of the high cost of casework and fume hoods, this can have a significant impact on the recycled-content credit.

Consider the LEED calculation:

"Use materials with recycled content such that the sum of post-consumer recycled content plus one-half of the post-industrial content constitutes at least 5% of the total value of the materials in the project."[94]

Within a given product, the calculation is based on weight, favoring the heavier recycled-content carpet backing over face fiber, for example. For the same reason, there is no significant LEED-based incentive for using flyash unless the amount used is at least 40%, earning an innovation credit.[95]

For an additional cost, Trespa lab bench tops can be used in place of conventional epoxy or phenolic resin benchtops. Trespa contains 15% recycled-content wood fibers and resins and 70% rapidly renewable content. It is made from a durable, fused composite material that uses no epoxy but is somewhat more expensive than conventional phenolic or epoxy systems.[96]

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[94] USGBC. *LEED™ Green Building Rating System for New Construction & Major Renovations* Version 2.1, revised March 14, 2003. Available at: www.usgbc.org/LEED/publications.asp.

[95] Although a pre-approved innovation credit now exists for using 40% flyash concrete. See the Credit Interpretations Page: www.usgbc.org/Members/Credit/credit_main.asp

[96] Trespa North America See: www.trespanorthamerica.com.

Kewaunee, Fisher Hamilton, and possibly other distributors sell FSC-certified laboratory casework, although there is currently a 15 to 20% upcharge for their product.[97] While this may be an option if wood casework is important to a project, metal casework is likely to be more cost effective.

The cost of using most low-emitting materials would be equivalent to that of non-lab projects. The paints and coatings credit, however, may be difficult to attain if highly chemical resistant paints are required. Safecoat makes a low-VOC product, but most qualifying paints are not chemical resistant and therefore not suitable for lab situations. Metal casework with a low-VOC electrostatic powdercoat finish is a standard product from multiple manufacturers and would not have a first-cost impact. Designers should avoid the specification of casework painted in dip tanks for durability reasons.

Mitigate design costs

Table 9 summarizes laboratory cost factors and ways to minimize these without reducing building performance. Architects, engineers, and users are primarily responsible for addressing these factors in most cases.

Table 9. Design Cost Factors

Cost Factors	Mitigation Strategies
MEP load	The lab users or owner should work with the design team to create a realistic maximum anticipated load to avoid oversizing power, ventilation, and cooling systems.
Design air requirements	Consider what levels of air filtration, ventilation, temperature and humidity control, pressurization, exhaust treatment, and fume hood face velocity are required. Can reducing air exchanges during non-use hours reduce energy use in the building?
Degree of standardization	Determine if all the lab modules can be the same. Consider ducting all the rooms for fume hoods in the same locations and standardizing equipment locations and types to save on construction costs by keeping the design simple to build.
Duplication of services	Design a centralized glass washing area to avoid plumbing every sink in every lab with hot water. Find out if the project requires multiple manifold systems or whether local water polishers and other services will be adequate. Avoid the duplication of unneeded services.
Type of laboratory	Classroom laboratories have very different usage patterns than research laboratories. The type and intensity of research can lead to very different cost determinants. Be sure to consider the time of day and duration of use when calculating energy savings.
Flexibility of building users	Find out early on if the users support potential innovative changes that may affect the way they use the building.
Plan for growth	Carefully consider the costs and benefits of planning for expansion capability. Expansion can be a very useful and environmentally sound way to meet future needs without having to build an entire new building. But it also can mean building expensive features now that may never be used.

[97] Communication with Kewaunee sales representative.

Other issues like vibration isolation and security requirements may play a significant role in some projects but generally have little impact on implementing green building measures.

Select the appropriate level of customization

The more customization a laboratory project requires, the more expensive it will be. If the building requires a wide range of laboratory configurations, the architect can best control costs by creating a series of templates that the researchers can choose from, altering only what is absolutely necessary for their research. Each laboratory should be designed with equivalent services and service locations; any services not required in the initial configuration should be capped inside the wall, ready for future installation. In addition to services, the following items should be standardized within a lab module:

- Doors and windows;
- Casework configurations;
- Circulation patterns and dimensions; and
- Locations of fume hoods and other major equipment.

For safety and cost savings, locate the following items at the same place in each laboratory: eyewash stations, first aid kits, blankets, safety showers, emergency shut-off switches, and alarms. This standardization helps to minimize installation cost and maximize flexibility for future configurations. Also, standardized locations for safety equipment can save time and confusion in emergencies.

Design to incorporate appropriate flexibility

Laboratories have highly controlled, specially programmed environments that require sophisticated equipment, controls, and special layouts and finishes. A common problem is that owners regularly request more stringent controls and complex programs than are actually needed. Owners are often aware of and attribute their overspecification to accommodating future needs, and in some cases find it is easier to finance a single, more expensive construction project than to obtain funds later for future additions and renovation.

While it may be worthwhile to increase project cost to fully accommodate potential future needs, the owner should be made aware of how much that flexibility is costing them. The owner should be given the opportunity to make an informed decision between the original program specifications and less expensive alternatives. If this opportunity is not provided, the more flexible/higher cost scenario becomes the default.

Flexibility should be pursued in the following areas:

- Space planning for laboratory layout;
- Placement of shafts and mechanical rooms;
- Control parameters for temperature, humidity, filtration, and ventilation; and
- Modularity of built-in equipment and furniture.

Designers should determine the level of flexibility required for any laboratory facility. Flexibility issues include adaptability, adjustability, and expandability. An easily adaptable lab would be a basic configuration that could accommodate a wide range of uses with only a minimal amount of equipment change. An easily adjustable lab would be made up of components that were moveable, depending on changing research needs with only basic labor requirements, no heavy

construction work, and no impact on adjoining spaces. Expandable laboratories allow for the easy reshaping of modular components to create or add new spaces and/or functions.

If the laboratories are likely to be reconfigured for changing research needs, the design team should consider modular lab sizing, doorways and fenestration; adjustable, movable casework; and plug-and-play modular services. These features are typically found in laboratory incubators but should also be considered in any facility with frequently changing research needs. Design teams should address this issue early with the owner because of its potential impact on building programming, services, and budgeting. Though a small amount of built-in flexibility may not have an additional cost, most features that provide flexibility will have a moderate increased up-front cost. These changes will, however, reduce retrofit costs and associated material waste and may even extend the usable life of the building. When considering adjustability, the design team should also determine what ADA requirements the laboratories will have and how to best include casework for wheelchair access.

Ultimately, science is unpredictable. While the design team should work with the researchers early on to determine the possible uses for the space, they must also understand and accommodate the inherently evolving nature of technology.

Designing standardized lab modules with appropriate flexibility can provide a significant savings in capital and renovation costs. Architects should create a series of laboratory plan templates that the users can choose from, altering only what is absolutely necessary to the research. Modular laboratories should all have equivalent services and service locations; any services not required in the initial configuration should be capped inside the wall, ready for future installation. Though the capacity for all services in all laboratories may seem redundant and costly, the standardization can actually save capital cost. To further reduce costs, the following items should also be standardized within a lab module: doors and windows, casework configurations, circulation patterns and dimensions, location of fume hoods and other major equipment. For laboratories that will likely be reconfigured for changing research needs, adjustable, movable casework, and plug-and-play modular services designed into modular laboratories—though increasing the up-front cost—will reduce retrofit costs and associated material waste throughout the life of the building. The designer and owner should work together to determine the appropriate balance of standardization and flexibility, keeping in mind the inherently evolving nature of science and technology.

Renovation

Carefully evaluate all options for renovation and new construction; the most cost effective options may not be obvious at first glance. At times, renovating existing laboratories to serve new laboratory uses can be cost effective. This depends on the closeness of existing and new uses, including MEP, space height and structural requirements. Often, however, project teams will find that it is more cost effective to build a new laboratory building and renovate the existing building to meet other needs, such as office or classroom space. In most cases, when siting is not an issue, renovating a non-lab building into a lab building will be less cost effective than new construction. The existing building would need to have high floor-to-floor heights and otherwise be able to accept laboratory infrastructure. Unlike some other building types, current demands of laboratory equipment and systems are such that new construction, when feasible, is likely to be less costly than renovation. The details involved can vary dramatically between projects; teams should carefully evaluate all possible options before making decisions on the best value.

In most cases, laboratories should not be located in rehabilitated older buildings and therefore will not be eligible for the building reuse credit. Non-laboratory buildings can rarely be remodeled to suit laboratories properly, and even old laboratories are often unsuitable for new lab

facilities and uses. The most significant limiting factor is floor-to-floor height. HVAC, lighting, and other equipment needs require a 12-to-16-foot floor-to-floor height or more, though anything under 13 feet is likely to present a major challenge and is not recommended. The mechanical shafts are an additional challenge to retrofitting an existing structure. Although building reuse may potentially offer a cost savings, there may be compromises in efficiency, quality of space, and key adjacencies.

Reducing plenum height may help to reduce capital and building lifecycle cost. Strategic placement of services, lighting, and ducts can help to minimize the plenum and the overall floor-to-floor height. In some laboratories, the drop ceiling can be removed; and installation of acoustical metal decking can replace the acoustic properties of ceiling tiles in many situations. This allows for a lower floor-to-floor height and gives the space a larger feel while eliminating ceiling materials. Laboratory partitions should already extend to deck in most cases. If ceilings are deemed necessary for washability, aesthetic, or other reasons, creative configurations of mechanical equipment in the plenum may allow for increased ceiling height near windows, improving daylighting. Ceilings with high reflectivity can also help to bounce light into the room. Reducing the ceiling height of the laboratories themselves is not typically recommended, however, because of daylighting and direct/indirect lighting opportunities.

On the other hand, use of a more substantial interstitial space that allows for easy access can provide improved maintenance capabilities and increased flexibility in the HVAC system over the life of the building. This strategy would incur a substantial capital cost, and that should be weighed against the potential need for future mechanical reconfiguration.

Truman State University needed to renovate its outdated Magruder Hall science building and dramatically increase its teaching and research spaces in order to bring together all four of the university's science disciplines. Initially, the university had intended to gut rehab the two existing, adjoining buildings while building an addition. The project team found, however, that the most cost effective solution was to keep only one of two existing buildings and construct a more substantial new addition. One of the two buildings had a structural grid and layout that was considerably more conducive to current needs. The team was able to design around the low floor-to-floor height of the existing building by eliminating drop ceilings in laboratories, installing acoustical metal decking, specifying high quality direct/indirect lighting and designing MEP systems with a relatively low profile. The renovation to an existing, outdated building will be seamless with the new addition; the two components will appear to be one, consistent building. While the university did not gain the resource efficiency of keeping both buildings, the new facility will serve their needs much more successfully, and with fewer compromises, for years to come.

RESOURCES

Cooper, E. Crawley. *Laboratory Design Handbook*. ISBN 0-8493-8996-8. Boca Raton, FL: CRC Press, 1994. Available for purchase at: www.uswaternews.com/books/bksbycategory/4iEnvCheGeneral/ld0849389968.html.

Mills, E. et al. *Energy Efficiency in California Laboratory-type Facilities*, Lawrence Berkeley National Laboratories. 1996. Available at: www-library.lbl.gov/docs/LBNL/390/61/PDF/LBNL-39061.pdf.

Federal Energy Management Program (FEMP), www.eere.energy.gov/femp.

Hill, R. et al. *Laboratory Fume Hoods Recommended Practices*, SEFA 1 – 2002, Scientific Equipment and Furniture Association, 2002. Available at: www.sefalabs.com/forms/..%5CForms%5CSefa-1.pdf.

HOK. Sustainable design case studies, research and publications, See: www.hoksustainabledesign.com.

Laboratories for the 21st Century, See: www.epa.gov/labs21century/index.htm.

Labs for the 21st Century. *Environmental Performance Criteria*. Available at: http://labs21.lbl.gov/docs/Labs21EPC2-0_10-1-02.pdf.

Building Technologies, Applications Team, Lawrence Berkeley National Laboratories. *Design Guide for Energy-Efficient Research Laboratories*. Version 4.0. Available at: http://ateam.lbl.gov/Design-Guide/.

National Renewable Energy Laboratory (NREL), See: www.nrel.gov.

Ruys, T., AIA. *Handbook of Facilities Planning, Vol. One, Laboratory Facilities*. ISBN 0-442-31852-9. Ruys, Theodorus, AIA, ed. New York: Van Nostrand Reinhold, 1990.

U.S. Green Building Council, See: www.usgbc.org.

Multi-Family Affordable Housing

CONTEXT

The case for greening affordable housing is substantial. The resident population is already at risk, so the social benefit of constructing healthy homes with low operating costs is large. Most developers who build affordable housing have a long-term stake in the operation of their communities so solid investments that pay back in 10 to 15 years are feasible, unlike with market rate homes, where the return on investment must be rapid. The challenge, of course, is to secure financing for green projects. This chapter provides specific cost management strategies for multi-family affordable housing that build on the guidelines presented in the General Strategies section.

Tight funding restrictions have historically precluded much deviation from standard construction practices in affordable housing. Until recently, for example, some HUD grants could be applied toward the installation of air conditioning in appropriate climate zones, but could not be used to build overhangs or other passive cooling devices that could eliminate the need for cooling altogether.[98] Now, however, most regulations are no longer preventing green building and some funding sources are beginning to recognize the benefits and understand the potential capital cost implications. Despite this, most projects must remain within standard budgets. When planned and designed appropriately, projects can achieve at least a basic level of green with little to no additional capital cost.

Architecturally, multifamily affordable housing projects are similar to for-profit multifamily projects; the biggest differences lie in the funding structure and the facility management. The quality and durability of materials in for-profit housing is set by market demands and tends to cover a wider range of unit types, sizes and designs as compared to affordable housing. Affordable housing developers are motivated to consider durability and maintenance costs when selecting materials; market rate housing developers only consider such issues if residents are willing to pay for upgrades from less expensive options. For-profit developers are also likely to build a larger variety of unit types than affordable housing developers, leaving affordable housing developers less flexibility in building configuration and orientation than their market rate counterparts. In affordable housing projects, standardization decreases capital costs, while variety in market-rate housing can help sell or rent units.[99] Marketing is not usually a significant factor in affordable housing projects since most buildings have long waiting lists.

Affordable Housing and LEED

Most multifamily housing tends to be very different from the public, commercial and institutional projects that typically use the LEED Rating System for new construction and major renovation projects (LEED-NC). Many green building practices are affected by differences in construction methods, systems, codes and materials that exist between commercial and residential projects. In addition, multifamily projects can only certify under LEED-NC if they are four stories or greater, though all projects can use the rating system as a design tool.

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[98] Communication with Larry Mayers of Michael Willis Architects

[99] *Ibid*

While some LEED credits are directly relevant to multifamily construction, others are not. For example, some of the credits in the Indoor Environmental Quality section are especially challenging to interpret in a multi-family building.[100] Credits such as Controllability of Systems can be easily adapted to residential projects, while others such as Carbon Dioxide Monitoring are less relevant. In addition, LEED-NC does not address issues that are important in multifamily construction, such as carbon monoxide detectors and Energy Star™ appliances.

Achieving the LEED credit for development density is another challenge that might plague affordable housing developers. Despite meeting the intent of the credit when building on infill sites in an urban neighborhood, the required density levels may not be reached in most residential neighborhoods, especially those that are likely to have vacant buildings. For example, High Prairie Apartments in Chicago could not meet the requirements for the density credit, despite the fact that it is a four-story development at 64 units per acre in an urban environment. Although the new building will be located on a site well suited for development, and the surrounding neighborhood has a large number of run-down, empty properties, the project does not meet the density values required by LEED.[101] LEED does not explicitly give credit to projects that help instigate future development in fringe neighborhoods—one of the biggest green benefits of good affordable housing.[102]

A second problem is associated with the use of brownfield sites. While sites might actually be located in brownfields, some projects will not document the LEED credit because developers can be hesitant to publicize the fact that their project sites are brownfield redevelopments. Though viewed positively by LEED and environmentalists, brownfields are often regarded negatively by funding sources and potential occupants.[103]

Guidelines for greening affordable housing

Though LEED can be a useful tool for greening affordable housing projects, a number of other resources and guidelines specific to green affordable housing are available. Global Green's Greening Affordable Housing Initiative has published *A Blueprint for Greening Affordable Housing: Developer Guidelines for Resource Efficiency and Sustainable Communities* and a number of related resources.[104] This document, paired with a green building checklist such as LEED or Alameda County's *New Homes Construction Green Building Guidelines*[105] can help project teams overcome two of the most significant barriers in greening affordable housing: lack of a good green plan and lack of resources. Guidelines and information specific to greening affordable housing are also available from the cities of Portland[106] and Santa Monica,[107] New Jersey,[108] and available in 2004 from Alameda County.[109] The Green Affordable Housing

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[100] Communication with Robin Raida of Community Corporation of Santa Monica.

[101] Communication with Susan King of Environ HarleyEllis and USGBC registered project data, www.usgbc.org see information on Project ID=611.

[102] LEED credit interpretation rulings for the Urban Redevelopment credit, July 2003. Available at: www.usgbc.org/Members/Credit/credit_main.asp.

[103] Communication with Susan King of Environ HarleyEllis

[104] Global Green USA's Green Building and Cities resources: look under Programs and then Building at www.globalgreen.org.

[105] Alameda County Waste Management Authority resources, See: www.stopwaste.org/fsbuild.html

[106] Portland Development Commission and City of Portland Green Building Initiative. *Greening Portland's Affordable Housing Design and Construction Guidelines to Improving Environmental Performance, Tenant Health, and Long-Term Durability in Affordable Housing,* Available at: www.sustainableportland.org/AHGuidelines.pdf.

[107] Santa Monica Green Building Program. *Green Affordable Housing Checklist*, Available at: http://greenbuildings.santa-monica.org.

[108] New Jersey Affordable Green strategy matrix available from www.state.nj.us/dca/dhcr/njgreenhomes.htm.

Coalition provides a reasonably comprehensive listing of additional resources for the San Francisco Bay Area, California, and the U.S.[110]

Cost issues

Green projects researched for this report had construction budgets from 0% to 5% larger than budgets for conventional affordable housing projects. In some cases, design teams with standard, fixed dollar-per-square foot budgets were still able to green their projects through integrated design practices; reducing costs in one part of the building helped the teams afford green upgrades in other areas. In some projects, additional dollars were available, allowing developers to include more expensive items, such as efficient HVAC systems or durable flooring.

Some green demonstration projects, however, had budgets that were 10 to 12% greater than standard affordable housing projects. In those cases, projects received special funding to implement green measures from government agencies, utilities and non-profit organizations. While demonstration projects are essential in teaching about new possibilities and bringing green building to the attention of affordable housing developers and to the general public, many green measures are not currently feasible in conventionally funded projects. Funding for demonstration projects is limited; though conventional funding sources increasingly acknowledge the benefits of green building, very few affordable housing projects can access money to increase their budget by more than a few percent.

Despite barriers, green planning and design can be done for little or no extra money, depending on the experience of the consultants and the goals of the project. As with any other building type, investing a small amount of extra money up front on things like energy modeling and commissioning can save costs over time. The costs of LEED documentation, on the other hand, fall well out of reach of most affordable housing project budgets: the relative cost of LEED documentation on residential projects is usually too large to consider even with the streamlining in LEED NC 2.1.[111] While a LEED rating might enhance marketing efforts of for-profit developers, it is only likely to help those affordable housing projects that have a demonstration function.[112] As of October 2003, affordable housing projects accounted for only three of the more than 700 projects registered under LEED 2.0 and 2.1 and none of those had been certified.[113]

The cost of urban infill sites

Urban infill projects, though typically the most sustainable development option, present potential barriers for green design. Infill locations can provide the best transportation and employment access for residents. However, they come with limitations. While these projects may be the most socially and environmentally responsible, they can also be more costly.

Lots available for affordable housing projects are often those passed up by other developers. Infill parcels may come in unusual shapes and sizes and are often comprised of a number of small lots instead of a single more efficient lot. Smaller lot sizes can reduce the unit densities on a given site, consequently increasing total design and construction costs. One study of California projects

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[109] Alameda County Waste Management Authority. *Multifamily Affordable Housing Green Building Guidelines. A*vailable early in Spring of 2004. Check www.stopwaste.org for availability.

[110] See: www.greenaffordablehousing.org

[111] Communication with Larry Mayers of Michael Willis Architects.

[112] Communication with Robin Raida of Community Corporation of Santa Monica and Jeff Oberdorfer of First Community Housing.

[113] USGBC. Project List. See: www.usgbc.org/LEED/Project/project_list.asp.

indicated that developments with financial assistance had an average density of 17 units per acre, whereas market rate development densities averaged 20 units per acre.[114]

Site constraints can also limit building orientation and configuration. Densities necessary for economic feasibility, tight sites within existing street grids and little flexibility in unit type and layout can all prevent the project team from maximizing the orientation and configuration of the building(s). Often the designers have only a few compatible unit types that can fit together to form acceptable building configurations. In order to make space on the site available for parking and shared outdoor spaces, designers' options are increasingly limited.[115] While building as few different unit types as possible might be cheapest, this limits the potential passive solar features of units with different orientations around the site.

Fitting and ameliorating parking requirements on a constrained site can be an additional challenge. Codes typically require developments to provide 2.5 parking spaces per unit for three bedroom units – imposing significant space requirements and possibly reducing housing densities on constrained sites.[116] Studies commissioned by the Non-Profit Housing Association of Northern California indicate that many affordable housing projects are required to provide more parking spaces than the residents require; the minimum requirements do not accurately represent the car ownership rates.[117] However, according to many developers, affordable family housing projects are not much different than other multifamily projects; the need for parking depends heavily on the availability of mass transit, bike and pedestrian options, employment and shopping. Finally, some projects must have relatively high numbers of parking spaces to satisfy needs of the surrounding neighborhood.[118]

Local codes

Codes in some jurisdictions limit specific green measures, such as greywater use or water-free urinals, however no more so than for other building types.[119] Variances are sometimes available and can save money in the long term.[120] However, because obtaining a variance may require additional time, project teams should talk early with their local code officials, and building and public works departments.

Local density and parking requirements for multifamily housing in some jurisdictions can also conflict with a developer's interests. These should be considered on a case-by-case basis, considering the health of the development and the surrounding community. Because maximum densities tend to be lower for suburban projects, those sites will not enjoy the same economy of scale that a denser urban project might achieve.[121] Less dense suburban sites, however, are more likely to have flexible spaces for construction waste management and may have more options for natural stormwater management and building configuration and orientation.

The high degree of code variation between municipalities can add cost to projects. For project teams working in different cities or counties and using different sets of codes, all of the small

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[114] Sam Davis. *The Architecture of Affordable Housing*. Berkeley, CA: University of California Press, 1995.

[115] Communication with Larry Mayers of Michael Willis Architects

[116] Davis, 1995. Op. Cit.

[117] Non-profit Housing Association of Northern California, *Planning for Residential Parking: A Guide For Housing Developers and Planners*. www.nonprofithousing.org/actioncenter/toolbox/parking/index.atomic.

[118] Communication with Robin Raida of Community Corporation of Santa Monica and Larry Mayers of Michael Willis Architects.

[119] Communication with Walker Wells, Global Green USA.

[120] Davis, 1995. Op. Cit.

[121] Communication with Carolyn Bookhart of Allied Housing.

variations in regulations, such as for life safety, can be frustratingly inefficient. One developer in Berkeley, California estimated that should elements such as sprinkler systems, floor assemblies, alarms and acoustics be standardized, they would save about 10% of project costs, enabling them to build 10% more units.[122]

The absence of individual interpretations or special considerations may also hinder the greening of affordable housing projects. For example, one developer interviewed from San José, California would like to include more pervious surfaces in projects to promote reduced stormwater runoff. However, the planning and public works departments continue to require that they install the same size sewer system as they would if they were using asphalt, thus negating any potential cost-savings for down-sizing the sewer lines.[123] In Chicago, a project team was interested in using a concrete form masonry unit exterior wall system that would provide a reduction in material use, an increased R-value and high thermal mass. Though not actually non-compliant with code, the lack of an existing interpretation for such systems in the city's code office would have resulted in a long and drawn-out process for the project team, adding unrealistic delays to their project schedule. In response, the team reluctantly reverted back to conventional design and construction methods.[124]

Materials information

In commercial projects, many green substitutes are available for conventional products. Fewer green product equivalents are available for the residential market, however, and project teams often need to specify commercial grade products in order to use a more environmentally preferable option. When this is the case, a premium is often incurred for the higher-grade material as well as its increased sustainability. For example, when a commercial project wants to improve the composite wood in its casework, the team might substitute a formaldehyde-free medium density fiberboard (MDF) for conventional MDF. In a residential project, however, the team would have to substitute a formaldehyde-free MDF for a much less expensive paper-wrapped melamine. As the market grows, more green residential grade options will be available, but until that time, many projects will incur increased capital costs for using green, commercial grade products.[125] These products are often of higher quality than their residential counterparts and can increase durability of affordable housing projects.

Further complicating specification of environmentally preferable alternatives, many green products do not have data available for installations more than ten years old; this lack of quantifiable data keeps some developers from specifying green materials. While there is often not enough general information available for green products and systems, there is even less for those that were installed more than ten years ago.[126] Despite limitations, many proven products do exist. Third party testing (e.g., from ASTM, ISO and UL) is widely available, and the presence of aging installations is growing. Detailed product research can help teams make good decisions on material selection.

How funding sources can restrict or discourage green building

Complicated funding mechanisms and the often separate owner/tenant relationship in multifamily affordable housing projects can create barriers to greening. For example, the Community

[122] Communication with Mike Rogers of Resources for Community Development.

[123] Communication with Jeff Oberdorfer of First Community Housing.

[124] Communication with Susan King of Environ HarleyEllis.

[125] Communication with Lynn Simon of Simon and Associates; Walker Wells of Global Green USA.

[126] Communication with Carolyn Bookhart of Allied Housing.

Corporation of Santa Monica cited problematic pro forma requirements in the financing of Colorado Courts, a demonstration affordable housing project with zero net energy consumption (the project produces the same amount of energy it consumes). Because a funder's rules prevented them from including the benefits of energy efficiency and solar power in the pro forma, the project at first appeared to fall short of the required minimum operating expense. In addition, because the building was master metered, it needed a larger line item for utility use than it would have otherwise, even though the building was designed to produce its own energy. Despite these barriers, the developer indicated that it is cost effective to borrow additional money up front to pay for energy efficiency measures that will pay back over time.[127]

Other funding sources can also either place restrictions on or refuse to fund specific items. The City of Chicago's Department of Housing, for example, refuses to pay for natural linoleum. The California Housing Finance Authority, if interpreted strictly, appears to prohibit anything but vinyl flooring.[128] In contrast, the New Jersey Affordable Green program can serve as a positive role model for other states' financing mechanisms by funding or helping to fund a wide range of green initiatives, from material upgrades to green roofs.[129]

MANAGING COSTS

The following section addresses the issue of how to approach a green affordable housing project from a cost management perspective. Approaches include, but are not limited to, appropriate design for the specific project type, thoughtful material selection, leveraging external funding sources and focusing on measures that produce multiple benefits and operational savings.

Leverage green measures to secure external funding

Project teams can use green building to access funding in two basic ways: leverage their green designs to improve their chances of receiving conventional funding, and/or seek out money specifically for green or energy efficient buildings. In California, projects can help to secure tax credit allocations by achieving points for sustainability and location efficiency.[130] The California Tax Credit Allocation Committee (CTCAC) recognizes the following sustainable measures (projects can receive up to a maximum of eight points, with up to three of those from the latter six measures):

- Beat Title-24 by 15% or, for renovation projects, beat existing energy use by 25% (5 points);
- Use of Energy Star appliances and heating and cooling systems (1 point);
- Use of natural gas for cooking and space heating (1 point);
- Use of occupancy sensors to turn off lights for all bathrooms, garages, and storage spaces (1 point);

[127] Communication with Robin Raida of Santa Monica Community Corporation.

[128] Communication with Susan King of Environ HarlyEllis and Larry Mayers of Michael Willis Architects.

[129] Communication with Darren Port of the New Jersey Green Homes Office.

[130] California Tax Credit Allocation Committee, See: www.treasurer.ca.gov/ctcac/ctcac.htm.

- Use of fluorescent light fixtures for at least 75% of light fixtures or comparable energy efficient lighting for the project's total lighting throughout the compliance period (1 point);
- Use of simple, low water landscape or irrigation design that reduces water use by a minimum of 10% over conventional irrigation designs (1 point); and/or
- Use of formaldehyde-free or fully sealed particleboard or fiberboard for all cabinets, countertops and shelving (1 point).

In addition to the sustainability points, developers can also receive up to 15 points for transit oriented development and sites with amenities relevant to the project population. Implementing renewable energy systems and additional sustainable measures can also increase the dollar amount of eligible tax credits. Projects can attain an additional 5% basis boost for including renewable or distributed energy technologies, and projects that meet at least three of the following measures are eligible for a 4% basis boost:

- Exceed Title 24 standards by at least 20%;
- Use Energy Star rated refrigerators, dishwashers, clothes washers, furnaces and air conditioners;
- Use gas ovens, stoves and clothes dryers;
- Use tankless hot water heaters;
- Use linoleum or ceramic tile for all kitchens and bathrooms (where low toxic adhesives or backing is also used);
- Use natural fiber woven carpet, recycled-content carpet, recycled carpet tiles, cork, bamboo, linoleum, or hardwood floors in living rooms and bathrooms (where low toxic adhesives or backing is also used);
- Use Energy Star rated roofs; and/or
- Provide wiring for computers in each unit.

Mercy Housing's 48-unit Nueva Vista project in Santa Monica, California makes good use of the tax credit basis boost available for sustainability and renewable energy sources. A 9% tax credit project in 2002, Nueva Vista received a 3% basis boost for its energy efficiency measures and a 5% basis boost for its photovoltaic system. These combined boosts provided an additional $500,000 to offset the up-front costs of the improved materials, equipment, and systems. Mercy Housing also took advantage of a rebate program for the photovoltaic system through the California Energy Commission.[131]

Though not yet widespread, green-specific funding is increasingly available from local housing authorities and other municipal sources. In Santa Monica, for example, the city will increase funds available to green projects.[132] Additional money may be available through loan, rebate, utility and design assistance programs.[133] Government agencies and local utilities often provide technical support. For projects in Pacific Gas and Electric's territory, for example, the Non-Profit Housing Association of Northern California, with the help of housing and energy experts, is

[131] Energy Action. Energy Action Finance Guide: Resources for Funding Energy Efficiency Technologies in Multifamily Housing. May 2003. Available at: www.energyactionresources.org/Energy-Action-Finance-Guide.pdf.

[132] Communication with Robin Raida of Community Corporation of Santa Monica

[133] See the Green Affordable Housing Coalition's "Financing" page at www.greenaffordablehousing.org for more information.

running the "Energy Action" program to improve energy efficiency in multifamily affordable housing projects, offering services to property owners and managers.[134]

Rebate programs may also apply. Research state, county, municipal and utility options. Though helpful in the long run, rebates can complicate the affordable housing budget process because savings are not available until the end of the project. For the Colorado Court project, the Community Corporation of Santa Monica was able to borrow additional money up front from the City of Santa Monica, with the understanding that the developer would use the rebate to repay their loan.[135]

A lack of additional funding should not get in the way of basic green design. Through an integrated, informed design process, teams may discover that they require less funding than they initially anticipated for fairly significant levels of green building.

Focus first on low-cost or no-cost green measures

For many projects, greening multiple small items such as flyash concrete or Energy Star appliances will be more cost- and time-effective than including higher priced green items such as greywater or photovoltaic systems. Focus first on those measures that can be included with little or no added cost. Though teams should certainly consider all relevant options and funding opportunities, they should not forget the basic, easier measures.[136] Under most circumstances, the higher priced measures will cost the team time, money and frustration, though early conversations with the contractor or an experienced cost estimator can help to define which strategies are most cost-effective.[137] Should a project have an unusual funding structure or be a special demonstration, then the project team should certainly consider such exemplary measures. Without extra funding, however, projects are likely to be more successful addressing a wide range of simpler and cheaper elements.

Though options will differ for every project, a wide range of green measures exist that may be incorporated into a project with little or no added cost. Developers and architects have identified items in Table 10 as practical, low- or no-cost measures in multiple projects.[138] Many measures have also been selected by Global Green's Greening Affordable Housing Initiative as a part of their *Top 20 No- or Low-Cost Green Building Strategies*.[139] Experienced project teams found that many green measures add no cost, and for a modest 2-5% budget increase they can accomplish a higher level of sustainability when strategies are planned for early in the design process.[140]

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[134] Energy Action See: www.energyactionresources.org.

[135] Communication with Robin Raida of Community Corporation of Santa Monica.

[136] See Global Green USA's *Top 20 No or Low-Cost Green Building Strategies* for more information, available at www.globalgreen.org/programs/20ways.html.

[137] Communication with Walker Wells of Global Green USA.

[138] Communications with Carolyn Bookhart of Allied Housing, Larry Mayers of Michael Willis Architects, Jeff Oberdorfer of First Community Housing, Robin Raida of Community Corporation of Santa Monica, Mike Rogers of Resources for Community Development, Helen Degenhardt of JSW/D Architects.

[139] Global Green USA. *Top 20 No or Low-Cost Green Building Strategies*, 2003. Available at: www.globalgreenusa.org. See the resources listed at the end of the report for further information on these strategies.

[140] Communication with Jeff Oberdorfer of First Community Housing, Carolyn Bookhart of Allied Housing Inc. and Lynn Simon of Simon and Associates.

Table 10. Common low- or no-cost green measures

Site & Building Design	Water Efficiency	Energy Efficiency	Materials & Resources	Indoor Environmental Quality
Orient building to maximize glazing on north and south facades. Reduce parking requirements where appropriate. Install secure bicycle parking. Provide pedestrian friendly pathways and bike friendly road access. Install motion sensors on site lighting where appropriate.	Design drought tolerant landscapes. Specify aerators and low flow showerheads and faucets. Design for natural stormwater management.	Design openings to provide natural ventilation. Specify a "cool roof." Specify whole house or room ceiling fans. Install hydronic heating systems. Specify fluorescent lights with electronic ballasts. Install low-e double glazed windows. Install Energy Star appliances. Design for thermal mass	Replace at least 30% of Portland cement in concrete with flyash. Specify engineered lumber. Specify recycled content carpet and insulation. Use efficient framing techniques such as spacing studs 24" on center. Specify local materials. Recycle construction and demolition waste.	Specify low- or no-VOC paint. Seal composite wood in casework or use products without added urea-formaldehyde. Vent bathrooms and the range hood to the outside with a quiet Energy Star fan. Specify insulation without added formaldehyde. Install carbon monoxide detectors.

Resources for Community Development and JSW/D Architects considered sustainable options early in a bay area project and, as a consequence, the team is including a number of no- or low-cost green measures in their Bayport Housing project in Alameda, California. Among these are 5/8-inch gypboard throughout for stiffness, acoustics and thermal mass; Energy Star appliances; insulated window frames; high efficiency landscape irrigation, including a vegetated swale system; engineered truss joists; high efficiency combined hydronic space and water heating systems; recycled content carpet and low-VOC paint.[141]

Identify (or create) a green champion in the developer's office

While architects can push a green agenda and include many green measures without adding cost, the most successful green projects have a champion in the developer's office. Many developers become interested in green because of funding requirements, through CTCAC or local municipalities, and many have personal commitments to the environment and to the health of their tenants. If this is not the case, the team can lose significant opportunities. Though developers should rely on the experience of the architects and contractors, they should develop and maintain their own sustainability goals and quality control processes throughout the buildings' planning, design and construction. A developer's consistent commitment to green building is one of the most important factors in a successful project because it is their enthusiasm and direction that ultimately sets the tone for everyone else on the project team.

Include green measures throughout design until "the last minute"

Planning and budgeting for a green project as early as possible is essential. Though developers should include as many green measures in initial budgets as possible, teams should include additional green measures in the planning and design process, even if they do not think they will be able to afford them down the road. Often, any item that does not fit within the budget cap of the initial pro forma is simply rejected. However, green materials and systems deemed too expensive should be left in the drawings until last-minute cost decisions can be made. Though

[141] Communication with Mike Rogers of Resources for Community Development and Helen Degenhardt of JSW/D Architects.

some items may not have a place in the base bid, they may be attainable within the project's contingency budget. If removed from the base bid, these features should become alternates, available if contingency money remains. Because of potentially long lead times, once a team has closed the door on a green measure it might be costly or impossible to upgrade at the last minute, forcing the team to default to a less desirable option. By including the green elements in design and construction documents throughout the process, the price for these alternates is locked, should funding become available.[142] While not all green elements are easily added or removed from a project, some, such as materials or equipment, should be sufficiently independent to define as alternates.

Plan for green to minimize change orders and open the door for alternates

Minimizing change orders during construction can leave developers more of their contingency open to allocate for green alternates. First Community Housing in San José, CA, for example, holds the contractors to their original contract documents. By eliminating most change orders and planning for green alternates early in the design process, they are able to include a range of green elements not otherwise practical.

Bring contractor on board as early as possible

Projects will also benefit from bringing the contractor on board as early as possible. Though this may not be an option for some public projects, private developers should have little reason to avoid selecting a contractor at the end of schematic design or the beginning of design development. An open line of communication during design can keep costs down and prevent major surprises in the bid. Contractors can help provide expertise on labor costs, recent changes in practice and material procurement and lead times. The contractor can help foresee cost adds in seemingly simple items, or help to implement more cost effective ways of building green within the project budget.[143] Bringing the contractor in early will also help to reduce the "smells expensive" factor that can inflate costs during the bid process for unfamiliar details.

Consider appropriate site selection

When there are options available, developers should first consider pedestrian and bike friendly infill sites in transportation-, shopping- and job-rich communities. Because a significant amount of energy associated with any building is in transportation, selecting the right location is one of the most important and potentially cost effective ways of reducing the energy use of the residents; it also increases resident mobility and the potential for economic security. As mentioned earlier, a potential downside to infill is that it may constrain the design and lead to a more expensive structure. Nevertheless, the long-term transportation benefits outweigh any modest capital increases.

Craig Gardens, a 90-unit senior housing project, is located in San José, near shopping and public transit. The development provides 64 parking spaces (0.71 spaces per unit) along with free "Ecopasses" for the local bus, light rail and Outreach paratransit services.

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[142] Communication with Robin Raida of Community Corporation of Santa Monica, Walker Wells of Global Green USA, Jeff Oberdorfer of First Community Housing, Mike Rogers of Resources for Community Development.

[143] Communication with Walker Wells of Global Green USA.

Incorporate appropriate building orientation and configuration

Developers should pay careful attention to building configuration and orientation; where project teams can easily orient the building along the east-west axis – maximizing northern and southern exposures – this strategy may be one of the cheapest ways to save energy. When site constraints make this difficult, however, proper orientation can be very expensive. Though not an ideal circumstance from an energy use perspective, rotating a single building prototype in different orientations around the site can reduce costs and is a fairly common practice. When proper orientation is not possible, architects should still consider different shading and daylighting solutions that are appropriate to each façade.

When the project team began working on the Carmen Avenue special needs housing project in Livermore, California, the City of Livermore anticipated a northwest-southeast axis, given the angle of one of the streets that bordered the site. Instead of allowing the units to parallel this odd angle, the architects at Kodama Diseño developed a new unit type and shifted the plan to provide almost all of the units with both a north-south orientation and double aspect. This orientation maximizes daylighting and passive cooling strategies.

Give priority to green measures with operational benefits

When setting green building goals for each project, teams should focus on those measures that will provide direct benefit to the facility management, the tenants and the surrounding community. While this may not directly save money, it can help to make the decision making process flow more smoothly. Teams are less likely to want to cut green measures from the project when they realize that they are also cutting something that will directly benefit the building users. For example, energy and water efficiency measures in common areas will help to minimize the property management's utility budgets, and durable materials and a water efficient landscape will reduce ongoing maintenance and repairs. In projects that are not master metered, tenants will benefit from lower energy and water bills, decreasing the fluctuation in their utility bills from season to season and increasing their overall financial stability.

Project teams should approach developments not just as affordable housing, but also as healthy affordable housing. Because of the liability concerns associated with mold, developers are increasingly aware of indoor air quality. However, mold is not the only air quality problem, and developers should also pay careful attention to material off-gassing and emissions from household cleaners. Because new homes tend to be well sealed from the outside, toxic materials can build up inside, potentially causing harm to occupants from exposure.[144] Children and the elderly—two major populations in affordable housing—are especially susceptible to chemical toxicity. The US Environmental Protection Agency considers formaldehyde, vinyl acetate, and other chemicals to be hazardous air pollutants and is currently undertaking extensive testing. Development and aggravation of asthma and airway hyperactivity, from increased interior emissions levels, are among the EPA's concerns.[145] Defining a targeted initiative, such as constructing buildings with fewer risk factors for asthma or reducing tenant energy bills by a certain percentage, can further help to focus design efforts and funding priorities.

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[144] See the US Environmental Protection Agency's indoor air quality site for more information: www.epa.gov/iaq/

[145] US Environmental Protection Agency. *Formaldehyde / Vinyl Acetate / Acetaldehyde: Toxicological Review and Risk Characterization Based on Mode of Action.* Available at" http://cfpub1.epa.gov/ncea/cfm/recordisplay.cfm?deid=55587

Understand the restrictions of your project type and design accordingly

Understanding the subtle differences between types of affordable housing projects can help teams set design goals appropriately. Family housing will require more open space and may not be appropriate for irrigation-free landscapes if the owner is interested in providing grassy spaces for children to play. Some facility managers have concerns that children will pull up unprotected drip irrigation hoses, so these may not be suitable for all facilities. Landscape architects should therefore consider childproofing issues in their irrigation designs, possibly favoring bubblers and micro spray heads over surface drip systems. In addition, family housing typically requires more parking than senior housing or single room occupancy (SRO) buildings. The latter two project types often have more flexibility in site design. The decision of how to meter a building may also depend on the project type. Many SROs and senior housing facilities are master metered, while family housing projects tend to be individually metered. Residents are more likely to conserve energy when they are paying the utility bills themselves, however developers have more incentive to install efficient systems if the buildings are master metered. Unit sizes can also have an impact on the hot water heating systems; in some family projects, for example, a single tankless water heater may not have enough capacity but installing two units is not financially or otherwise feasible. Understanding these kinds of restrictions up front can help steer the design team to consider only measures relevant to the peculiarities of the individual project, thereby saving time and money.

Balance benefits and costs when selecting and procuring materials

Calculating the capital and life cycle costs of building systems and assemblies can be an important decision-making factor in green design. Because many affordable housing developers manage their projects for a long period of time, they have an incentive to install materials and systems that will save money over the long term. Engineers can often calculate payback times for increasing a building's energy efficiency and many durable materials have a longer life span than their less expensive counterparts. For example, while linoleum may have a more significant up-front cost than sheet vinyl, it will typically last two to three times as long, saving money over the course of its life and creating a healthier indoor environment for the building occupants. When comparing different materials, designers should also consider the value of a green material in helping to secure funding. For example, the slight increased cost for low-VOC paints and caulking is worth the minimal added expense simply on the basis that it is required by some funders and encouraged by others.

During schematic design of an affordable housing project in Emeryville, California, Siegel and Strain Architects received a grant from the Alameda County Waste Management Authority to research and develop a green design. Among their goals was to demonstrate that green affordable housing can be cost effective; particularly as they had little additional construction budget. In designing and constructing this project, they conducted detailed materials research to understand the costs of each building system and assembly, comparing them to standard materials and methods. They balanced the cost data with the benefits of improved environmental performance, ultimately constructing a better building within a conventional budget. When they compared their cost per square foot to a similar project under construction nearby, they found the costs to be almost exactly the same.[146]

[146] Siegel & Strain Architects. *Emeryville ReSourceful Building: Environmentally Sound Affordable Housing,* published by the Alameda County Waste Management Authority and communication with Nancy Malone of Siegel and Strain Architects.

Leverage economies of scale

Though not feasible on many projects, pricing materials for multiple projects at one time can provide economies of scale. Developers should consider forming relationships with product representatives and suppliers in order to gain the ability to price out multiple projects at one time. Project teams will need to commit to using a specific product ahead of time (and not veer from it in value engineering efforts) but they will benefit from an economy of scale. Developers who have architects and construction managers on staff may have an easier time with this than others, but any project manager who is able to hold to their specifications should be able to develop appropriate connections over time. If product representatives trust the developer to hold to their specifications, then the product representatives will be more likely to provide a good deal.[147]

Consider factory-assembled components or engineered products

While factory-assembled components or panels may save material and labor costs in some circumstances, energy efficient systems and green materials are often not available as standard options. For example, in an affordable housing project in Sacramento, California, the project team opted to use prefabricated panels to save on construction costs, but very few green upgrades were available.[148] While those prefabricated elements that involve material and system choices may not have green options, factory-assembled items can be inherently more resource efficient. One senior housing project used a prefabricated panel system with efficient framing techniques, saving lumber and other materials as well as capital cost.[149] Engineered lumber, trusses and other spanning elements also typically use considerably less wood than their equivalent lumber products.

Use green elements to mediate a simple design

Green elements can be used to help bring character to an otherwise architecturally simple structure. Simplifying the building design is a common cost saving strategy among affordable housing designers and other architects alike. Standard dimensions and recurring parts can help save money, but they can seem unimaginative if unmediated with some degree of variation in form or color. Affordable housing projects should be architecturally friendly and distinctive to both the residents and the surrounding community. Project teams can use green building measures to balance the conflicting interests of simple, low cost solutions and a dynamic architectural design. Architects may be able to use green elements with a clear economic payback as justification for interesting architecture. Awnings, balconies and other shade devices, for example, can help add life to a project while reducing residents' utility bills; a passive ventilation design may include opportunities for atypical, interesting building openings and unit designs.

Communicate openly with operational stakeholders

The creation of a good maintenance plan, including operations and maintenance staff training, is crucial to the success of all projects, but is particularly essential for green projects, where life cycle savings from building operations are often used to justify increased up-front investment. Keep an open communication loop between those who manage the properties and those who make design decisions so that project managers can incorporate any relevant lessons learned into the planning process for their next projects. The developer should also ascertain feedback from

[147] Communication with Jeff Oberdorfer of First Community Housing.

[148] Communications with Mike Rogers of Resources for Community Development.

[149] Communication with Susan King of Environ HarleyEllis

residents regarding air quality, utility bills and durability and cleanability of materials. If problems arise, do not automatically toss out the troublesome elements in the next project. Instead, try to determine the core issues and solve them creatively without sacrificing the human or environmental health components.

RESOURCES

General Resources:

Global Green USA. Greening Affordable Housing Initiative and *A Blueprint for Greening Affordable Housing.* 1999. Available at: www.globalgreen.org.

Green Affordable Housing Coalition. See: www.greenaffordablehousing.org

Non-Profit Housing Association of Northern California. *Planning for Residential Parking: A Guide For Housing Developers and Planners.* Available at: www.nonprofithousing.org

US Green Building Council's LEED™ Rating System. Available at: www.usgbc.org.

Local programs:

Alameda County Waste Management Authority. *Green Guidelines for New Home Construction,* New Edition Released July 2003. Available at: www.stopwaste.org.

Association of Bay Area Governments. *Blueprint 2001 for Bay Area Housing: Housing Element Ideas and Solutions for a Sustainable and Affordable Future*, 2001. Available at: www.abag.ca.gov.

New Jersey Department of Community Affairs Division of Housing and Community Resources. *Sustainable Development/Affordable Housing Pilot Program.* Available at: www.state.nj.us/dca/dhcr/sdhome.htm .

Portland Development Commission and City of Portland Green Building Initiative. *Greening Portland's Affordable Housing Design and Construction Guidelines to Improving Environmental Performance, Tenant Health, and Long-Term Durability in Affordable Housing.* Available at: www.sustainableportland.org/AHGuidelines.pdf.

Santa Monica Green Building Program. Santa Monica Green Building Guidelines and Santa Monica Green Affordable Housing Checklist Available at: http://greenbuildings.santa-monica.org.

Funding Information:

California Tax Credit Allocating Committee. See: www.treasurer.ca.gov/CTCAC/.

Energy Action. *Energy Action Finance Guide*: *Resources for Energy Efficiency in Multi-family Housing*,. May 2003. Available at:www.energyactionresources.org See also list of projects in PG&E's territory.

Case Study Listings:

Department of Energy High Performance Building Database, case studies on Colorado Court and Denver Dry Building, Available at: www.eere.energy.gov/buildings/highperformance/case_studies.

Jonathan Rose and Companies, green affordable housing case studies, See: www.rose-network.org.

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