High Profile at Low Cost: Introducing a Multi-Family Residential Market To High-Performance Building Design and Construction

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ABSTRACT

High-performance "green" building design and construction provides energy efficiency along with resource conservation, low life-cycle cost, and occupant comfort and health. Split incentives often undermine architects' and builders' willingness to experiment with green building, despite many potential advantages. In regions with low utility costs, green building advocates face even more difficulty convincing the building community to try innovative methods.

The present project educated residential designers and builders in the advantages of whole-building integrated design and created a high-profile local example of green building. Grants totaling $26,000 from the municipal government, state energy office, and USDOE paid for the region's first high-performance building design charrette, post-charrette technical support, and production of materials disseminating the project's results. A seminar introducing high-performance building (HPB) drew over 30 developers and architects and solicited projects for the pilot charrette. A competitive process selected the local housing authority's application to focus on 18 six-unit apartment buildings within a HOPE VI urban revitalization project. Other public events and media coverage expanded interest and knowledge regarding HPB before and after the charrette.

Charrette participants included housing authority staff, the design-build team, experts from the state energy office and non-profits, and local government staffers. The charrette-designed buildings will significantly reduce energy and water use, and will incorporate many materials recycled or salvaged from the site. The experience and positive publicity acquired in this project will foster widespread application of HPB goals and methods in the region.

Starting Point: More Interest than Incentives for High-Performance Building

Louisville, the largest city in Kentucky, has a metropolitan area population of about one million. One regulated utility supplies virtually all electricity and natural gas, with no choice of suppliers by customers. The state has no systems benefit charge, and current demand-side management programs of Louisville's electric and gas utility do not include any measures aimed at increasing energy efficiency of new buildings. In 2000, over 97% of electricity supplied to the Louisville market came from coal-fired steam turbines. The abundance of inexpensive Kentucky coal provides for very low electricity prices for residential customers, about 32% below the national average ($0.0576/kWh vs. $0.0845/kWh in 2002). Residential natural gas prices held at about 8% below the national average ($7.27/Mcf vs. $7.91/Mcf in 2002) (Kentucky Public Service Commission 2004; DOE EIA 2004).

Low energy prices and little policy-level support have impeded investments in energy efficiency in the region. Nonetheless, public and municipal interest in high-performance building has increased along with rising awareness of fuel price volatility, environmental consequences of coal-fired electrical generation, health hazards of poor building design and construction, and

environmental costs of construction and demolition. To date, the region includes only one ENERGY STAR-labeled building[1] and no LEED-certified buildings. Building commissioning remains unusual and few architects or homebuilders promote green or energy efficient building features to prospective clients. Architects note the difficulty of finding contractors willing to work with structural insulated panels (SIPs), geothermal heat pumps, or other techniques or subsystems not commonly in local use. Initial cost continues to dictate design choices. Regarding his incorporation of energy efficiency into commercial projects, one local architect said, "I would love to do more, but the market doesn't allow me to."

Goal: Creating Regional Momentum Toward High-Performance Building

This project sought to increase local demand for HPB, increase local capacity to deliver it, and begin transforming the regional building market to improve the energy efficiency and environmental performance of new buildings. To this end, the project aimed to increase the public demand for HPB, help educate the building community how to meet that demand, and create a successful example of HPB in Louisville.

Introducing the Local Design-Build Community to HPB Design and Construction

In the absence of a local green building program or incentives for performance exceeding code requirements, all impetus for higher energy efficiency or environmental standards comes from building clients. This project aimed to introduce developers, architects, and builders to green building techniques including:

- HPB design charrettes
- Whole-building integrated design
- Building commissioning
- Construction details to minimize infiltration and heat transfer
- Site design and building orientation to conserve energy and water
- Recycling and reuse of construction and demolition debris

Increasing the Performance of a High-Profile Building Project

High-performance buildings benefit their occupants (through improved comfort and health), owners (through lower life cycle costs), and the public at large (through lower energy and water demand and reduced environmental impact) (Kats et al. 2003). A local building embodying green design provides a powerful tool for promoting additional green building projects. We aimed to demonstrate advantages of high-performance design and construction process including:

- Higher energy efficiency
- Lower water use and stormwater runoff
- Reduced construction waste

[1] The Aegon Center, a large commercial building.

- Reuse of materials recycled from old buildings on the site
- Improved indoor air quality and indoor comfort
- Reduced life cycle costs

Further, we sought a building project that would further the city's urban revitalization goals and, if possible, serve low-income members of the community. The ideal pilot project would have significant interest to the public even in the absence of any innovative design. This public interest would lead to more opportunities to promote the innovative design methods and their results.

Encourage Regional Application of HPB Techniques

In addition to creating a local example of green building, the project took other steps to foster adoption of green building techniques regionally. Goals included developing local capacity to conduct building design charrettes and building energy modeling with minimal reliance on distant consultants. This lowers the incremental cost of high-performance design in the Louisville market. Developing knowledge and enthusiasm about green building among municipal officials, another goal, may influence the city to incorporate HPB goals and techniques into its standards for facility design, construction, and renovation. The Louisville Metro government owns and operates numerous buildings, many of which see use by the public. As such, Metro government could create local demand for green architecture as well as bringing its benefits into public awareness. A combination of increased local expertise, higher demand, and lower incremental costs could speed the use of high-performance design and construction in the region.

Getting There From Here

With a relatively small investment, this project engaged the interest of key development officials and building professionals and stimulated the use of HPB techniques in a high-visibility building project. Funding from US Department of Energy through Kentucky Division of Energy (the state energy office), with in-kind contributions from local partners, supported the project with a total budget of about $17,000 cash and $9,000 of in-kind services. The project proceeded in four phases: introductory seminar and competition; design charrette; post-charrette technical support; and documentation and dissemination of results.

Introductory Seminar and Competition for Design Assistance

Grants funded a two-day high-performance building design charrette and post-charrette technical support for one building project in Louisville Metro. This charrette was the first of its kind conducted in the Louisville area. To attract a developer committed to taking full advantage of this design assistance, we awarded it through a competition. In consultation with development officials and other members of the building community, we compiled a list of developers and architects interested or involved in urban infill or redevelopment projects. Each person on the list received basic information on the competition for $15,000 of free design assistance, along with an invitation to a free breakfast seminar on high-performance building design. At the seminar, architecture professor Richard S. Levine, director of the University of Kentucky Center for

Sustainable Cities, gave a 45-minute presentation on high-performance buildings citing examples from around the world. Professor Levine's presentation stressed examples of high energy efficiency and building performance with construction costs no higher than those of commonplace buildings. After the presentation, audience members received details about the charrette competition along with a competition application form. Judging from the lively question-and-answer session during the seminar and enthusiastic conversation afterwards, the presentation stimulated interest in application of green building practices locally. Over thirty people attended the introductory seminar.

Four developers or architects submitted applications to participate in the design charrette. All four applications described projects fulfilling urban redevelopment goals. The four submittals all showed interest in using the charrette process to optimize the environmental performance and energy efficiency of the resulting building or buildings. The project partners considered four applications a satisfactory response.

We did not survey seminar attendees regarding their reasons for applying or not applying for the design charrette. Some attendees noted that they did not have qualifying buildings in the initial planning phase during the project's time frame. We hypothesize that others chose not to apply because they did not anticipate that the charrette would bring economic benefits sufficient to offset the inconvenience of adding a step to the design process.

For two reasons, the project partners selected the application from Louisville Metro Housing Authority for buildings in their Clarksdale neighborhood revitalization project. First, Clarksdale is a 70 year-old public housing community undergoing complete demolition and reconstruction under a HOPE VI grant from US Department of Housing and Urban Development (HUD). As such, it serves low-income residents and has a high potential to benefit the community at large. Any innovations at Clarksdale stand to receive much media attention. Second, the Housing Authority had already assembled the funding needed to proceed with the project. The private-sector projects submitted to the charrette competition all hinged on funding not yet assured at the time of the competition.

Design Charrette

The Clarksdale revitalization will replace barracks-style public housing with a variety of owner-occupied and rental units ranging from heavily subsidized to market-rate to create a mixed-income neighborhood. The Louisville Metro Housing Authority (LMHA) charrette award application called for using the design assistance for one of several building types planned for Clarksdale. At the time of the charrette award, LMHA had yet to select the lead architect for the Clarksdale project. LMHA made participation in the charrette a condition of the architecture and engineering contract, recognizing the importance of participation by the architects, mechanical and electrical engineers, and landscape architects.

After LMHA chose the architect (Sherman, Carter, Barnhart of Lexington, KY), project partners met to discuss charrette plans. The group chose to focus the charrette on six-unit apartment buildings ("six-plexes"), of which LMHA plans to build eighteen. LMHA agreed to employ the charrette-influenced design on at least one of the eighteen six-plexes. Construction costs, design time requirements, and ease of construction will dictate whether design features developed during the charrette get incorporated into more of the six-plex buildings.

Upon selection of the architect, project partners assembled a list of charrette participants. LMHA agreed to the invitation of several local officials and building technology experts not

otherwise affiliated with the Clarksdale project. Charrette participants included three architects and two landscape architects from Sherman, Carter, Barnhart (SCB), five architecture and engineering consultants subcontracted by SCB, five staff members from LMHA, five staff members of Metro development and environmental agencies, and seven outside experts. The latter group included a professor of ecological design from Berea College (Berea, Kentucky), an expert in sustainable landscaping from Bernheim Forest and Research Arboretum (Clermont, Kentucky), the program manager of a local non-profit housing corporation, the director and a research fellow from the Urban Design Studio, and two staff members from Kentucky Division of Energy (the state energy office). The seven outside participants brought experience from USDOE Building America and high-performance school programs, numerous programs to build energy-efficient homes, and the state's first two projects seeking LEED (Leadership in Energy and Environmental Design) ratings. A team of three staff members from Southface Energy Institute (Atlanta, Georgia), a non-profit organization that promotes energy efficiency and green building, conducted and helped plan the charrette.

A "briefing book," a hyperlinked set of documents distributed on CD-ROM, was created and sent to participants in advance of the charrette. It included conceptual drawings of the site and planned structures, background on Clarksdale, information on whole-building integrated design and green architecture, a list of potentially useful building components and subsystems, and extensive links to other resource material. Prior to the charrette, Southface and project partners assigned each participant to one of three working groups: Site & Water, Energy & Indoor Environmental Quality, and Materials & Indoor Environmental Quality. These working groups created most of the recommendations that emerged from the charrette.

The Urban Design Studio (UDS), in downtown Louisville, hosted the charrette. The UDS, a collaborative venture of University of Louisville School of Urban and Public Affairs, Louisville Metro Department of Planning and Design, and University of Kentucky School of Architecture, conducts neighborhood design charrettes and graduate courses. The UDS staff has expertise in planning and architecture as well as a strong interest in sustainable design. The UDS also served as the venue for the introductory seminar.

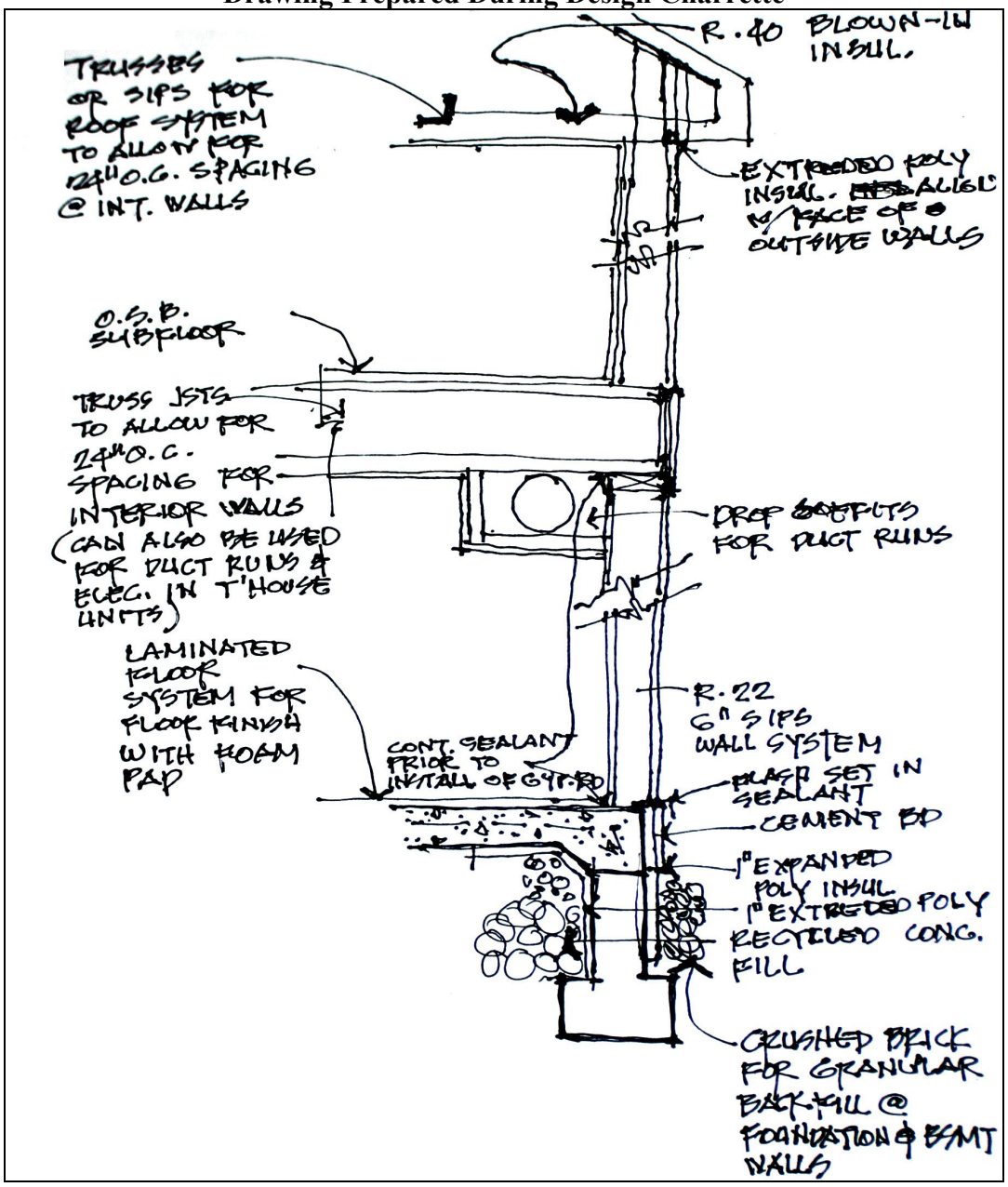
A site visit prior to the charrette developed familiarity with the building site for participants without previous knowledge of the site. During the first morning of the charrette, Southface presented an introduction to HPB design and construction methods and described common HPB goals. The three working groups then convened and developed goals for their respective areas of concern. Throughout the charrette, Southface provided technical support to the working groups. The group gathered in plenary to review and refine the work of the small groups.

The charrette resulted in the recommendation of over twenty design goals and dozens of means to meet them. Architectural decisions regarding the building exterior and site plan, made prior to the charrette, limited options for daylighting and passive solar heating. The buildings will have three stories, with façades that blend with the traditional design of the surrounding neighborhood. Skylights, clerestory windows, light shelves, oversized windows, and other features not compatible with the chosen building façade designs did not receive consideration during the charrette. Primary energy-related recommendations from the charrette include:

Wall construction: 8-inch structural insulated panels (SIPs). The SIPs allow a high whole-wall insulation value with minimal infiltration, and are available from a local manufacturer.

Roof construction: truss framing with R-40 blown insulation. An engineered truss with raised heal allows high insulation level with low cost. Figure 1 shows a drawing, made during the charrette, of a preliminary proposed wall and roof section.

Figure 1. Suggested Roof and Wall Section for Six-Unit Apartment Building – Drawing Prepared During Design Charrette



HVAC: geothermal. Using three wells per building (one well per two units) reduces initial cost and damage to roots of existing trees. Each unit will include its own well-field pump and water-side heat pump to allow individual control and metering. Heat pumps will include desuperheaters to provide most domestic hot water at no additional energy cost.

Lighting: fluorescent, with electronic ballasts. Use compact fluorescent lamps in most locations. Include both ambient light sensors and motion detectors on outdoor fixtures. Design outdoor lighting to minimize glare and light trespass.

Appliances: ENERGY STAR. Each unit will include ENERGY STAR-labeled dishwasher, clothes washer, and electric water heater. Assuming all-electric geothermal HVAC with a desuperheater supplying most domestic hot water, using electric water heaters will obviate the expense of installing natural gas lines.

Building commissioning. At a minimum, test for infiltration to ensure air tightness of 5 air changes per hour at 50 Pa and 0.25 air changes per hour under natural conditions, according to the Lawrence Berkeley National Laboratory infiltration model. (Meier 1994) The Energy & Indoor Environmental Quality working group recommended commissioning the building shell and HVAC system, subject to cost constraints.

Participant evaluations gave consistently high marks to the Southface team for charrette content and facilitation. Participants found the time well spent, and showed enthusiasm for refining and implementing the ideas brought forth during the charrette.

Post-Charrette Technical Support

The charrette report, a hyperlinked document distributed on CD-ROM, included updated site drawings and building conceptual drawings as well as key resource material on HPB design. Each charrette participant received a copy of the report to serve as a starting point for detailed cost estimating and design. The report came with a reminder of the availability of grant-funded technical support to all members of the design-build team.

At this writing, the Clarksdale buildings are in the schematic design phase. LMHA and SCB have requested and received information on successful local residential applications of geothermal HVAC systems and on local geothermal contractors experienced with residential installations. LMHA and SCB have requested a life cycle cost comparison of geothermal HVAC with gas furnace plus standard air conditioning as well as refined estimates of labor and material costs for SIP wall construction.

Reaching the Project's Goals: The Road Ahead

Continuing Work on the Present Project

About three months after the charrette, LMHA engaged a developer partner to oversee construction and potentially to manage the property after building completion. The involvement of a developer partner further complicates the allocation of operating cost savings. Each six-plex will include market-rate, tax credit, and subsidized rental (public housing) units. For subsidized units, HUD pays utility bills and currently provides little financial incentive to tenants or property managers to reduce energy use. Tenants in tax credit units pay their own utility bills. In these units, lower utility costs may decrease tenant turnover. For market-rate units, increased energy-efficiency would presumably increase marketability at any given rent level. It remains unclear what fractions of the related financial benefits will accrue to the housing authority and to

the developer partner. To promote above-code energy performance for subsidized units, project partners face the challenge of quantifying non-energy benefits to help justify incremental costs for energy efficiency measures.

The HUD HOPE VI grant requires a tight schedule for the Clarksdale project, with large monetary penalties for late achievement of milestones. The project also has a very tight budget. These constraints dampen enthusiasm for techniques or equipment with which the developer partners and architect have limited familiarity. To meet the schedule for the first block of six-plexes, LMHA and SCB have chosen to use standard frame construction with gas furnaces and standard central air conditioners. For subsequent six-plexes, LMHA has challenged the charrette project partners to assemble an "upgrade package" of energy efficiency measures with a payback period of less than ten years based on energy savings. Upon accepting such a package, LMHA would seek external financing for any incremental costs. The system of development partners and the three tenant groups result in a daunting array of split incentives.

At this writing (May 2004), it remains unclear which recommendations from the HPB design charrette will make their way into the completed six-unit apartment buildings. Schedules, availability of qualified local contractors, and initial costs will largely determine this. The HOPE VI project schedule presses LMHA to build public housing units rapidly to replace units lost due to the demolition of the obsolete Clarksdale buildings. This militates for rapid construction of the first section of six-unit apartment buildings.

Ironically, some Clarksdale building types not considered during the charrette may benefit more from the charrette recommendations than the six-plex does. A building to house the management offices and community recreation facilities may offer more design flexibility, less pressing deadlines, and clearer financial incentives for energy efficiency. Market-rate owner-occupied homes would likely reward the developers' energy efficiency investments with higher sale prices. (Laquatra, Dacquisto, Emrath & Laitner 2002) Design specifics for lighting and HVAC for those building types will differ from those for the six-plexes. Some design features recommended during the charrette, e.g., SIPs and geothermal heating and air conditioning with desuperheaters for water heating, will nonetheless have relevance to several building types.

Beyond Clarksdale: Promoting High-Performance Building in Louisville

Beyond the Clarksdale revitalization project, several interconnected factors will affect the pace of adoption of HPB design and construction in the Louisville market. The region will soon have its first example of a LEED-certified building, the new visitor center at Bernheim Research Forest and Arboretum about 40 miles from Louisville. The building, designed by William McDonough + Partners and Barnette Bagley (Lexington, Kentucky), seeks to achieve a LEED Platinum rating. Bernheim is offering public tours and workshops regarding the building's sustainability features throughout its construction and after its completion. At least three other LEED-registered projects are underway in Kentucky. None, however, are located in Louisville Metro. Several regional HVAC, architecture, and engineering firms have collaborated to form a provisional chapter of US Green Building Council. This will help to increase the ability of local architects and engineers to meet any market demand for green buildings.

Such demand may be growing. Within Louisville Metro, environmental initiatives in progress have raised awareness of the possibility for public cost savings and environmental benefits through green building. Charrette participants from local government and non-profit agencies can carry the message of cost-effective high-performance design practices, encouraging

their adoption in publicly and privately owned buildings. The Metro government funded a five-week Louisville showing of the "Ten Shades of Green" exhibit created by New York Architectural League. (Buchanan 2000) This exhibition, launched with a press conference by the Mayor, spurred excitement for green building locally. External factors including fuel cost changes and changes in the regulatory environment (e.g., adoption of a Federal standard market design for electrical distribution or institution of greenhouse gas mitigation policies) could increase incentives for improving building performance.

Louisville Metro Air Pollution Control District intends to apply for additional funding to monitor the energy consumption of Clarksdale six-plex units with and without innovations arising from the charrette. Other planned work includes production of a video and a brochure documenting the project and promoting high-performance design and construction in the region. These work products will continue the progress establishing the benefits of HPB in our region and to bringing it into common practice.

Lessons Learned

The HPB demonstration program reported here had four primary elements:

- Introducing the design-build community to HPB design and construction
- Offering subsidized design assistance to a local design-build team through a competition
- Conducting a HPB design charrette with the winning team; and
- Providing post-charrette technical support and encouragement to maximize use of HPB elements in the buildings in question.

The first three elements went well; the success of the fourth remains unclear. The following factors emerged as important influences on the success of the HPB demonstration program.

Attracting the interest of the primary audience. We focused on architects and developers working in urban infill redevelopment. The offer of $15,000 of grant-funded technical assistance encouraged attendance at the introductory seminar on HPB design. Scheduling the seminar at a convenient time (early morning) also increased participation. The excellent "Ten Shades of Green" traveling exhibit provided another means of stimulating interest in HPB design among our target audience. Personal invitations to developers and architects encouraged their involvement and resulted in their referring us to other prospective participants.

Selecting a suitable partner. The competition for the grant-funded charrette and post-charrette technical support provided the opportunity to select our project partner from among several projects and project teams. We chose Louisville Metropolitan Housing Authority and its Clarksdale HOPE VI urban revitalization project to maximize public exposure of the green building practices and minimize the risk of investing the design assistance in a design that would never get built (e.g., due to inadequate financing). On those grounds, the Clarksdale six-plex remains a good choice.

Unfortunately, the complexity and scale of this HOPE VI project, combined with recent changes in the rules governing the HOPE VI program, have forced LMHA to give low priority to the HPB pilot project. The four-year Clarksdale project involves moving over 1,000 people,

razing dozens of buildings, creating a master-planned neighborhood of dozens of new buildings, and selling or renting hundreds of new units. In this context, optimizing the design of one six-plex does not compel management attention. Even the potential to reduce energy use and life-cycle costs for all eighteen six-plexes and perhaps for other building types must fall below the priority of meeting the many milestones set in the HOPE VI grant. Had the HOPE VI grant application included HPB goals, LMHA would have had strong incentive to meet those goals.

Program structure. Providing design assistance through a competition engaged the interest of many developers and architects in the region. The competition's judging process, though, did not adequately evaluate the applicants' incentives for following HPB practices. A package of design assistance has a monetary value dwarfed by the construction cost of any significant building. The developer and architect need other incentives – perhaps public recognition, a marketing advantage, or a share of operating cost savings – to attempt a new design method likely leading to a non-standard design. An agency considering a pilot program along the present lines can increase its success by choosing a project partner with strong incentives to take full advantage of the opportunity to show local leadership in green design and construction.

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