SUSTAINABLE CAPITAL PROJECTS: LEAPFROGGING THE FIRST COST BARRIER

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ABSTRACT

Multitudinous strategies, technologies, and best practices exist to improve the sustainability of a capital project, but comparatively few of these tactics have been successfully applied in green building projects without increasing first cost. Given typically constrained budgets available for capital projects, the challenge to project managers, designers, and other project stakeholders is to identify and justify the use of cost-neutral or cost-saving sustainability features that can be included on their projects to meet increasingly stringent sustainability goals set by project owners. The objective of this paper is to identify and describe a set of techniques for finding cost effective sustainability strategies for capital projects. The paper includes a case study of an exemplary capital project from the United States to illustrate a set of techniques for identifying cost neutral or cost saving project options. These techniques include effective problem framing, identification and exploitation of cost discontinuities through integrated design and right-sizing, dematerialization, leveraging of free resources, and holistic cost management. The paper includes an overview of each technique and recommendations for applying that technique in project planning, design, and implementation.

INTRODUCTION

A significant barrier to sustainable construction is the perceived likelihood of a first cost premium for sustainable projects. In some projects, this barrier inhibits sustainability from a business perspective, while in other cases it may completely filter projects from consideration. An increasing number of studies have both supported and refuted this perception (e.g., Kats 2003; Portland Energy Office 1999; Romm & Browning 1995; US DOE 2003; US Green Building Council 2004; Wilson 2005; Packard Foundation 2002; NEMC 2003; Winter 2004; SBW Consulting 2003; Pearce 2004), but conflicting evidence has only made the development of accurate cost models for sustainable construction projects more difficult. A better approach to cost estimating is needed for sustainable capital projects, including better methods for accurately estimating first costs of sustainable vs. traditional projects that account for *all* costs associated with a project in order to make sound investment decisions.

Despite commitment to developing sustainable facilities, many organizations are experiencing difficulty in implementing the concept due to the way in which funding is allocated to projects. Personnel responsible for developing project estimates have few resources for accurately estimating the first costs of a sustainable project, let alone potential life cycle cost impacts of sustainability. In many cases, the only method available for estimating sustainable project costs is to add a contingency factor to the estimate for a traditional project to cover anticipated increases in design costs, material costs, and other project costs, particularly for innovative projects in the early planning stages. This approach inhibits the implementation of sustainability for two reasons, particularly in public agencies. First, projects are often funded based on efficiency of

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first cost, meaning that projects with a higher parametric cost estimate are less likely to get funded; and secondly, adding a contingency to the project estimate means that even if the project does get funded, there is often no incentive to seek cost savings since the money will be lost if it is not spent, creating a self-fulfilling prophecy of increased costs for sustainable projects (Pearce 2001).

This paper presents a framework for understanding project costs from a holistic standpoint, establishes objectives and requirements for accurately understanding the true cost implications of sustainable projects, and identifies a set of best practices for overcoming the first cost barrier in sustainable capital projects based on case studies of public sector facilities in the United States. The next section describes the foundation for these practices: a new approach to facility costing and planning based on holistic cost modeling.

FOUNDATION: HOLISTIC COST MODELING

Figure 1 provides a means for examining expectations about sustainable capital project costs. The grid represents a way to plot the relative cost of a sustainable project vs. its traditional counterpart in terms of both life cycle and first costs. Figure 1(a) shows what most people expect about a sustainable project: it will cost more in the beginning, but will likely save money over the whole life cycle due to waste reduction, increased durability, reduced operations and maintenance requirements, etc. This expectation is illustrated by the red circle in the lower left quadrant of the diagram.

Yet within the present structure for funding projects, the only projects that will be funded without special intervention lie within the region indicated by green in Figure 1(b), i.e., those that cost the same or less from a first cost perspective. In many cases, funding constraints mean that minimum first cost is the goal, even though overall life cycle costs may be greater (the third column in the diagram). This sub-optimal result is possible because the sources of money for first cost vs. operations/maintenance cost are different and disconnected (i.e., the "color of money" problem).

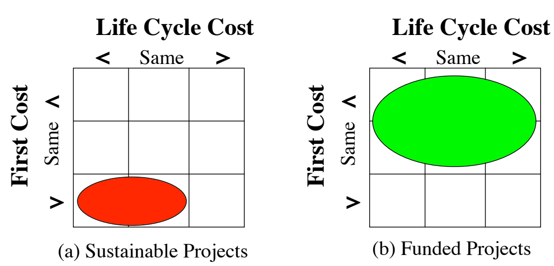

Figure 1: Expectations about Sustainable Project Costs (Pearce 2001)

The concept of holistic cost management considers the following from the very beginning of a project:

- What will be the impacts of design/construction decisions on life cycle costs?
- What opportunities exist to *offset* increases in first cost for design improvements?
- What externalities should be considered that could result in a better decision about costs?

Instead of the two-dimensional representation of cost shown in Figure 1, holistic cost management expands the figure along a third dimension to include additional cost/benefit considerations that are associated with the project. Figure 2 illustrates the revised cost model.

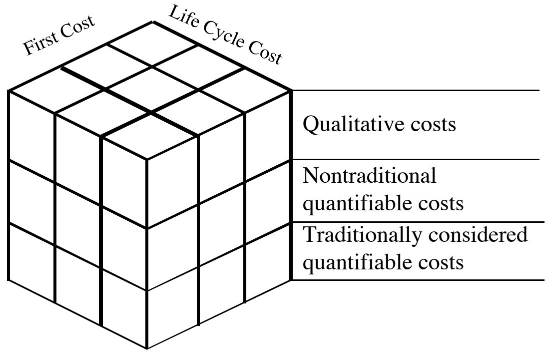

Figure 2: Revised Whole Project Cost Model (Pearce 2001)

The bottom layer of the figure represents the two-dimensional cost comparison shown in Figure 1. This layer represents traditionally considered, quantifiable costs that are typically calculated as part of project planning, and include site acquisition, design, management, and labor, material, and equipment costs for construction, operation and maintenance, and repair/remodeling. The second layer in the holistic project cost model consists of nontraditional but quantifiable costs. These are costs that can be quantified in terms of their economic impact, but which are not traditionally considered as part of the project decision process. Such costs include definite costs such as reporting and record-keeping, monitoring, and compliance assurance, and contingent costs such as remediation costs, productivity and absenteeism, and future liability costs that may or may not occur (Bennett & James 1998; Romm & Browning 1994; Pearce 2004).

The third layer of the holistic cost model consists of qualitative costs – those costs that have some real impact but are difficult to quantify because of societal values and other measurement challenges. It is at this level that sustainable projects truly dominate traditional projects in their impact reduction; however, the difficulty of assigning actual costs and benefits to specific projects is significant and therefore not typically considered as part of project decision making. Costs can be broken into two categories at this level: internal costs, and external costs. Internal costs are those difficult to quantify costs experienced directly by project stakeholders and include impacts on quality of life and value of environmental image. Externalities, on the other hand, are generally borne by society as a whole. While projects have some individual contribution to these costs, the net cost is a result of all human activities, and allocating specific responsibilities is difficult. Externalities include resource and ecosystem degradation, biodiversity loss, global climate change, and ozone depletion (ibid.).

This holistic model of cost, integrating both first costs and life cycle costs as part of project decision making, provides a basis for framing best practices in capital projects for surmounting the first cost barrier. The next section describes five of these practices used successfully on public sector capital projects in the United States.

BEST PRACTICES FOR LEAPFROGGING THE FIRST COST BARRIER

A variety of approaches have been tested to reduce the cost of building green, including increasing the efficiency with which we build and operate facilities and by avoiding costs that are traditionally associated with construction projects. For example, reducing the waste generated by a construction project can be paid for by savings in landfill fees and waste hauling. Construction recycling can result in payback by converting waste (a liability) into a useful resource needed by someone else (an asset).

In other projects, natural systems have been used to perform the functions traditionally provided by engineered systems at a significant reduction in cost. For example, living machines made of plants, snails, bacteria, and other organisms, natural drainage swales, and constructed wetlands can be used to collect and treat wastewater without requiring any input of chemicals typically needed by engineered conveyance and treatment systems. The result is healthy plants and purified water that can be safely used for other purposes.

In still other cases, any additional costs of construction have been offset by savings in the life cycle cost of construction. For example, installing more efficient but more expensive hot water heating, lighting, or HVAC systems can be paid back by savings in energy costs over the operational life of the building. Similarly, more durable but expensive materials such as concrete paving can be economically superior to less durable but cheaper materials such as asphalt if the life cycle replacement costs are considered.

How can these techniques be applied to capital projects? Five basic strategies can help to systematically leapfrog the first cost barrier in capital project planning and implementation. The following subsections describe these strategies in greater detail, in the order in which they should be considered to maximize impact on project cost for capital projects. These practices are followed by a case study from a public sector project in the United States to illustrate their use.

Solving the Right Problem

The first strategy for greening project within a limited budget is to ensure the right problem is being addressed in the first place. This means questioning the question, "how can I pay for a new building?" and asking instead if there might be more cost-effective and sustainable ways to meet needs than constructing a new facility. Leasing, rehabilitating existing buildings, telecommuting, flexible work schemes, and other similar strategies are examples of ways to leverage existing resources to displace the need to construct a new facility. Too often, building professionals leap into planning and designing a facility without considering other options that might offer significant advantages in terms of both cost and sustainability. In some cases, changing the problem being addressed could result in both sustainability and performance advantages at a much lower cost than creating a new structure (as illustrated by the case study later in this paper). In other cases, the most appropriate solution may still be to build new, but at least considering other options early in the process can result in a different mindset about the project that translates into greater creativity on later decisions throughout the project.

The key to solving the right problem is to focus not on solutions, but instead on the *need* potential solutions will meet. Decision makers who focus on the obvious or presented choices as the only options available may miss other solutions that are preferable in terms of overall objectives. Rephrasing questions in terms of the need being met (e.g., "how can I house my workers?") instead of solutions (e.g., "how can I build a new building?) help to open up the problem frame to previously unconsidered options. Decision makers that find themselves defining problem in terms of one or more solutions should consider taking a step back and reassess their options to take advantage of this strategy.

Integrated Design and Right-sizing

After choosing a problem frame that affords a broader perspective on how to meet project objectives, the next step is to use an integrated design process to come up with an optimized solution. Integrated design is a term used in two fundamental ways in the building industry – first, it refers to integration of the design *team* to include stakeholders not traditionally included in the process, such as constructors, future building occupants, and community stakeholders. These stakeholders contribute to the design process in many ways, ranging from identifying potential constructability problems that could lead to construction change orders, delays, or disputes, to pointing out issues that will be critical for achieving buy-in and reducing potential implementation barriers (e.g., Pulaski & Horman 2005).

Second, integrated design refers to a design process in which systems are developed in concert with one another rather than independently, and interrelationships between systems are exploited to optimize system performance and maximize cost savings. For instance, integrated design means that larger areas of high performance windows might be included as part of the building envelope design to provide for daylighting (raising total project cost), but the benefits of better envelope performance and reduced heat load from light fixtures are recouped by reducing the capacity of the building cooling system (lowering total project cost). Additionally, a smaller HVAC system might mean smaller pumps, fans, and motors, reduced duct sizes, smaller plenums, and reduced floor to floor height, also reducing the cost of the facility (Hawkin et al. 1999). The net increase in the total first cost of the project may be negligible if the benefits afforded by one system are captured in the design of complementary systems. More importantly, life cycle cost savings can be considerable with these more efficiently designed systems, particularly if HVAC systems are right-sized for the facility, allowing them to operate at maximum efficiency over the life cycle of the facility.

Dematerialization

A third strategy being used to surmount the first cost barrier to sustainability is dematerialization. Dematerialization refers to the substitution of *services* to meet needs that were traditionally met by the purchase of *goods* (ibid.). Office managers have successfully used this concept for years – the photocopier is a classic example of a piece of equipment most likely leased rather than owned, with a per-copy charge to the company that owns and maintain the machine. Rather than take ownership responsibility (and associated liability) for equipment, owners pay another company to provide the benefits of that equipment for their project. That company, often the manufacturer of the equipment, has an incentive to provide the most efficient equipment possible, since it reaps its profits based on some profit margin per unit of service provided. It also has incentive to design products that can be easily repaired, upgraded, or disassembled, since it retains responsibility for the ongoing maintenance and eventual disposition of the equipment.

A growing number of building systems and components, ranging from roof systems to flooring to mechanical and electrical systems, are available as services from companies who will install appropriate systems to provide a level of performance defined in the contract on a fee or pay-for-performance basis. Some companies also incorporate maintenance services to optimize the performance of their systems, since this ensures proper maintenance performed efficiently and on time. The primary advantage of dematerialization with respect to first cost is that the cost of these systems is typically shifted to an operational cost, thereby eliminating those systems from the total installed cost of the project. Often higher-performance systems can be afforded on a lease basis than could be afforded if the system were purchased and included as part of the project's first cost.

Leveraging Free Resources

While the facility is being optimally planned and designed and options for dematerialization are being explored, a variety of free resources exist to assist in further reducing the first and life cycle costs of the project. Depending on the nature of the project, its location, and the type of owner, a growing number of programs exist to promote and support the use of green building principles in its delivery. In the planning and design of the facility, technical assistance can often be obtained for no or low cost from government agencies, universities, local utilities, or non-profits. State environmental or natural resources agencies are often a good starting point to learn about these programs. A wide variety of grants are also available to fund investment in specific technologies (e.g., fuel cells, photovoltaics), environmental remediation of contaminated sites, or evaluation of facilities using green building standards (e.g., the LEED™ rating system). In some cases, manufacturers or utilities are willing to provide demonstration equipment for pilot projects at reduced or no cost, particularly for owners with significant facility stock who may be interested in widespread application of those technologies. Finally, tax credits, rebates, and financing assistance programs are also available in some locations to support the application of green technologies. Databases such as the Database of State Incentives for Renewables & Efficiency (DSIRE – see http://www.dsireusa.org/) provide regularly updated lists of available incentives to support these kinds of activities.

Holistic Cost Management - Counting All the Costs

The concept of holistic cost management considers a larger set of questions than traditional project costing from the very beginning of a project. For instance, what will be the impacts of design/construction decisions on life cycle costs? What opportunities exist to *offset* increases in first cost for design improvements (as in integrated design)? What externalities should be considered that could result in a better decision about costs?

Traditionally, project decisions are based on factors such as the costs of material, labor, equipment, and cost of money. Decisions about individual products are sometimes made on a unit cost basis without necessarily considering cost from a systems standpoint. This practice means that some products offering sustainability advantages seem more expensive than they really are. For instance, when asked why they don't use integrated building systems such as structural insulating panels or sheathed insulating concrete form blocks, many owners reply that these systems are more expensive than traditional methods such as concrete masonry construction. Yet if savings in labor cost and construction schedule were taken into account, these materials could show an immediate cost advantage to owners. For example, one U.S. federal project manager estimated a savings of $3,000 per day due to shortening the construction schedule on his project by using preengineered autoclaved aerated concrete systems – all from avoiding the cost of housing personnel in hotels instead of the facility being built as their residence (Eunice 2002) . Similar or even greater savings in opportunity costs can result on many other projects as well.

Other considerations, if taken into account, could more clearly indicate the benefits of sustainability in the built environment, such as:

- Reduced costs of consumption, waste disposal, and noncompliance
- Reduced liability and environmental risk

- Improved use of assets, particularly human assets (including increased productivity, reduced absenteeism and building-related health problems, improved morale, and better employee retention)
- Reduced operational and disposal costs
- Reuse of facilities that otherwise would be disposed
- Preparedness for future regulations and requirements

Each of these benefits reflects a potential cost savings for owners, although many of these kinds of costs are not typically associated with specific projects and the associated decision processes behind their funding. If these potential benefits can be realized, then sustainable projects will truly have an economic advantage over their traditional counterparts. The ultimate outcome of considering the full spectrum of costs associated with a project is a true picture of what costs and benefits will stem from each alternative over its whole life cycle. If all costs are considered, then actions which might ordinarily come back to haunt the decision maker (such as endangered species habitat disturbance or use of hazardous materials) can be adequately considered for the risk they truly represent.

CASE STUDY: HOMESTEAD AIR RESERVE BASE FIRE STATION

Consider the following scenario: the allocated project budget is just over half of what was originally requested, so the project team decides to use sustainability principles to get the project done within the budget provided. This seemingly unlikely strategy was adopted by the U.S. Air Force Reserve Command in charge of building a fire station at its Homestead Air Reserve Station in Homestead, FL. This 26,000 square foot project, completed in 2002, embodies a broad array of sustainable design and construction strategies, and has resulted in what its occupants believe will be a better building than would have been constructed under the original scenario (Cadle 2002).

The fire station was originally proposed as a new building on a greenfield site, needed to replace the existing, undersized fire station that suffered from a leaking envelope, poor internal traffic patterns, and an outdated communication system. When the project team learned that the amount of money available for construction was only $2.9 million instead of the $4.9 million originally requested, they decided to tackle the challenge by thinking outside the box, not downscoping the original plan. The original problem, how to build a new fire station under a very constrained budget, became a question of how to house fire fighting operations given the budget provided. By rephrasing the question to focus on the needs in terms of functional performance, other options beyond building a new fire station were able to be considered, such as the option to rehabilitate and expand the existing fire station. Under the direction of Col. John Mogge, then the MAJCOM Civil Engineer for Reserve Command, the team conducted a three-day sustainability charrette to come up with a design strategy for rehabilitating the existing fire station using sustainability principles.

The savings from reusing the main structure of the facility as well as avoiding the need for extension of infrastructure services to a new site afforded the opportunity to provide for firefighters' needs within the constrained budget. Additional savings were realized from including a percolation trench, which avoided the need for expanding the base's stormwater treatment systems. The contractor on the project was able to recycle nearly all demolition and construction waste on site, not only virtually eliminating tipping fees for solid waste, but also in many cases generating a revenue stream from selling segregated waste products to recyclers. The Air Force project manager for the project, Mr. Bill Cadle, commented on another side benefit of the alternative waste practices during construction, saying that clean up actually happened on a daily basis on the site to ensure proper separation, increasing construction efficiency and reducing the risk of accidents. The payoff from a safety standpoint was a project with zero lost time incidents.

A major key to the success of the project, according to Cadle, was the sustainability charrette at the beginning of the project. Using an innovative approach to procuring construction services, the contractor for the project was competitively selected at the *beginning* of the project, in time for contractor staff to participate in the planning and design process. Facility management, operations, and maintenance staff from the base were also included in the charrette process, along with the future occupants of the facility, representatives of the Wing command, and project management and procurement personnel from the headquarters level and the Air Force Center for Environmental Excellence. The charrette was a tangible culmination of the efforts of Col. Mogge, whose idea it was to champion this project as a sustainability pilot for AFRC. Through Mogge's efforts, the Wing Commander was sold on the idea of a sustainable fire station from a public relations standpoint, and personnel both at the base level and headquarters level were firmly committed to sustainability goals for this project. The charrette was used as both a planning and decision process for the facility program, as well as a means to educate and align all project stakeholders with the sustainability goals of the project.

CONCLUSIONS

The ultimate outcome of thinking creatively about the full spectrum of costs associated with a project is a true picture of what costs and benefits will stem from each alternative over its whole life cycle. If all costs are considered, then actions which might ordinarily have long term pitfalls for the decision maker (such as endangered species habitat disturbance or use of hazardous materials) can be adequately considered for the risk they truly represent. Figure 3 shows how sustainable projects compare with traditional projects when all these factors are considered. The sustainable project, indicated by the green dots, has lower non-traditional and externality costs compared to the traditional project, indicated by red. This two-dimensional representation corresponds to looking at the three-dimensional model from the side, and reducing first cost and life cycle costs to a single metric such as net present value for comparison purposes.

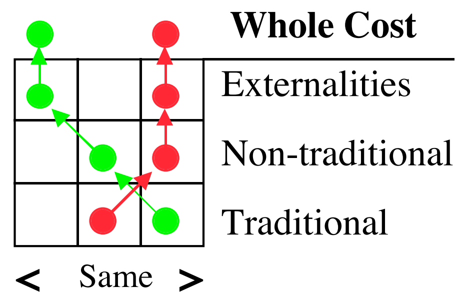

Figure 3: Sustainable vs. Traditional Projects from a Holistic Standpoint (Pearce 2001)

Additional factors that may result in reduced quantifiable costs for sustainable projects in the long term include:

- Learning Curve – as sustainable products and strategies become more familiar to designers and builders, less effort will be required to use them correctly

- Economies of Scale – as demand increases for sustainable technologies in the marketplace, production and distribution networks will grow and become more efficient
- Resource Scarcity – as many of the materials presently used in building (e.g., fossil fuels, old growth timber, mineral-derived products) become more scarce, their costs will increase and the cost of using alternatives will become relatively less expensive
- Stricter Legislation – as environmental, safety, and occupational health (ESOH) regulations become more restrictive, projects that have lower risk of ESOH threats will become relatively less expensive.

All of these external influences will tend to give advantage to sustainable projects from an economic standpoint, at least in the long run. In addition, significant advances are being made across the spectrum of building technologies, so designers should avoid falling prey to the assumption that emerging technologies which performed badly on past projects are still poor performer. One notable technological improvement is today's low face weight carpet: while many owners are still specifying the same 24 oz carpet they have used for years, newer low weight (16 oz) carpets are available that cost less, look the same, wear better due to greater stitch density and lower pile height, are easier to clean due to reduced surface area of fibers, and use less raw materials to produce (Pearce et al. 2001). These products and others are excellent examples of doing more with less – the true key to achieving sustainability in built facilities.

In conclusion, sustainability is becoming an important consideration for construction projects around the world. Sustainability offers a way of meeting the needs for which we construct projects, while avoiding the negative impacts traditionally caused by those projects. The ultimate goal of sustainability is our long term survival as the human race. The negative impacts of our present methods of construction can no longer be denied. The time has come to seek better ways of building that will maintain our quality of life and ensure that our children and their children can continue to live as well as we do. Thinking strategically about *how* we go about greening our projects can ensure that we are able to meet sustainability goals without breaking the project budget.

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