White Paper

The Economic Case for ~~"Green Buildings"~~ "High Performance Buildings"

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04/19/2000

1.0 Introduction

A well-planned approach to building design and development can lead to the construction of facilities that are green "both ways"--that is, facilities that are not only more environmentally-benign, and thus more sustainable, but also facilities that are more economically-beneficial for their owners and operators than those based on more traditional designs, processes, and materials. "Green buildings," or "high perfomance buildings" as they are increasingly being called, are being commissioned in growing numbers. As more of these facilities come on line, the data supporting the economic case for them is also growing, and that case is very compelling.

In fact, the interest level in designing buildings to be more sustainable is at an all time high. In Seattle for example, the Mayor this February proclaimed that all new City buildings will be designed to promote environmental quality through efficient management of energy, water, and material resources. To ensure that this takes place, he has pledged that the City will design all new buildings to adhere to the LEED 2.0 (Leadership in Energy and Environmental Design) "silver" level. LEED 2.0 is a self-certifying system, created by the U.S. Green Building Council, that allows building owners to accumulate "credits" for green design strategies. The credits then qualify the building for certification at one of several levels; LEED certified silver, gold, or platinum. Achieving even the silver level is no small degree of commitment, and with over 40 buildings currently in the development pipeline for the City, the impact of this pledge will be substantial. Other cities, including Portland, are also making great strides in identifying ways to promote sustainable buildings, and the States of Minnesota and Pennsylvania have also adopted "green" guidelines for facilities.

So, if sustainably-designed buildings and facilities have such great economic benefits, then why aren't more firms building them? The reason for this is likely due to the widely held perception that sustainable design costs more. This perception persists in spite of the growing body of evidence in the form of case studies and research that point to numerous categories of economic benefits from sustainably-designed buildings. Many of the current examples of green building in the private sector have been developed by organizations with long-standing "green" credentials such as: Patagonia, Interface, S.C. Johnson, and The Gap, or for special green building projects such as the 4 Times Square skyscraper in New York City. In these cases, the organizations are often perceived as willing to take the plunge toward environmental progress without hard proof of guaranteed economic savings.

Increasingly however, these "green" pioneers are being joined by other firms looking first for the economic benefits and secondarily for the environmental benefits of such facilities. This list is growing to include many of corporate America's biggest players. It currently includes names such as Lockheed, Alcoa, Armstrong, Duracell, Hermann-Miller, Quest, and Verifone, to name just a few.

This approach, that of focusing on the economic benefits first and the environmental benefits second, seems to be the most effective way of inculcating green design or whole systems design approaches into the modus operandi of modern facility development. While some experts on the topic such as Paul Bierman-Lytle of CH2M HILL believe that a design approach doesn't meet the definition of sustainable if it doesn't save money, the terms sustainable design, green design, and sustainable development have seemingly been saddled with the burden of being perceived as an extra-cost or luxury items. So much so, that proponents of green buildings are moving to the term "high performance buildings" to highlight the economic benefits of sustainable design and divert the focus from the environmental benefits in an effort to win over the skeptics. In the end, regardless of what we call the buildings or the approach used to develop them, both types of benefits, economic and environmental, are readily achievable through sustainable design.

2.0 The Economics of High Performance Buildings

The potential economic costs and benefits of facilities can be divided into four tiers (see Figure 1):

Tier 1- Traditional (known as Total Cost of Ownership [TCO])
Tier 2- Productivity
Tier 3- Image
Tier 4- External

These four categories of costs and/or benefits become substantially more difficult to quantify in a precise manner as one moves down the list from Tier 1 to Tier 4. Because of this, only traditional costs and benefits included in TCO are considered. Furthermore, difficult to quantify Tier 1 costs/benefits (e.g., resale value, deconstruction versus demolition, etc.) may also be left out of benefit calculations. The problem with such an approach is that an ever-growing body of evidence suggests that the magnitude of costs/benefits associated with Tier 2 issues could potentially dwarf the costs and benefits of Tier 1 issues. To put these two tiers in perspective, over a 30 year period, Tier 1 (TCO) costs account for just 8% of the total of Tiers one and Two (with Tier 2 accounting for the other 92%).[1] While no studies were found quantifying the potential of Tier 3 issues, for some firms, the potential could be substantial in this area as well. Tier 4 issues are those known as "externalities" in environmental economics parlance. While potentially very valuable to society as a whole, they do not directly affect the company's bottom line because they are external to our current economic system. Some companies, and certainly many governmental bodies, may wish to include these costs in their decision-making, and there are available tools for this purpose such as Pliny's Model.[2] However, for most firms, Tier 4 costs are not going to be compelling because of a failure to affect their bottom-line.

Tier 1 costs include the capital outlay required to design and build the facility (often referred to as “first costs”), and the operation and maintenance (O & M) costs for the facility based on its useful life-span. Of the 8% total TCO figure provided above, only 2% of the total is due to first costs and 6% is due to operation costs.[1] In other words, over the 30 year life of a building, an owner generally spends three times as much money to operate and maintain it as they do to design and build it. Furthermore, design costs are generally only 10% of the construction costs. Therefore, a building owner generally spends 9 times more to build a facility than to design it, and 30 times more for O & M than for design, and 460 times more to pay the people that will work in the facility (over its useful life) than was spent on the design.

So what? - you may ask. Well, the reason that all this is so important is because the opportunity to reduce almost all of the follow-on costs exists almost completely at the design stage. A stage where the facility developer is often in a hurry to get the project moving and attempting to meet a budget target which considers primarily first costs and few, if any, of the previously noted follow-on costs. Furthermore, incentives for designers to reduce these costs are almost completely non-existent. Designers are generally paid a fee based on the first costs of the facility, and, thus, potentially have no incentive to reduce those through sustainable design. Also, designers generally don’t share in performance improvements for the O & M portion of TCO costs, nor do they share in Tier 2 or 3 benefits. In order to achieve the potential longer-term benefits possible in the O & M, Tier 2, and Tier 3 areas, the design stage becomes more complex, difficult, and potentially more expensive than a more traditional approach, further discouraging an integrated or whole systems approach from the perspective of the designer.

Thus, we are left with two problems to resolve:

1. Convincing facility owner operators that the potential for long-term economic benefits (i.e., difficult to quantify Tier 1/TCO costs, Tier 2 costs/benefits, and Tier 3 costs/benefits) are worth the extra effort required for a whole systems design approach. This is discussed further in Section 3.0.

And,

2. Correcting the current incentive structure which discourages designers from taking a whole systems design approach. This is discussed in Section 4.0.

3.0 Economic Benefits by Tier

As noted previously, the potential economic benefits from high performance buildings come in four tiers. Examples of potential benefits in each of the first three tiers are discussed in the sections below. Table 1 provides case studies of real facilities which have experienced some of the benefits discussed below. Table 2 provides an overview of the categories of benefits and the types of design features associated with them. Note that all types of building features are not viable for all projects or locations. Each project will have unique economics which will drive the exact combination of high performance building features which are economically-viable. These site-specific issues include: site location, local conditions, available infrastructure, local taxes and fees, permit requirements, code issues, etc. Given a development scenario, a whole systems approach to design is used to determine which of these features make economic sense for the specific project in question.

3.1 Tier 1 Traditional (Total Cost of Ownership)

This section addresses high performance building features which offer the potential to reduce either first costs or O & M costs, or both. O & M costs are discussed first because the design measures that are generally taken in the first place to reduce O & M costs can also have an impact on first costs. For example, design and construction targeted to utilize passive heating and cooling may or may not increase some first costs (design and materials), but may also decrease others (the need for large HVAC systems). This logic applies to all of the examples provided in this section. Note that costs are discussed qualitatively in this section because the design feature costs and benefits are very site-specific, not because the savings are not quantifiable or verifiable.

3.1.1 Operation and Maintenance Portion of TCO

3.1.1.1 General Energy Efficiency Savings

High performance buildings are designed to be energy efficient from the start. This approach can result in a facility which reduces energy use by up to 70% using current technology versus traditional building design.[3] There are several different types of design approaches that can be used to drive significant energy use reductions. Some examples of these are identified below.

<u>Improve the building envelope</u>- Approaches to improve the building envelope can be one of the most effective ways to reduce energy use. Approaches include the use of super-insulation in walls, thermal envelopes around the structure, high performance windows, low emissivity glass, etc. Integrating photovoltaic panels into the skin or passive solar shading systems can also reduce on grid energy consumption.

<u>Design the structure to utilize passive solar energy</u> - Buildings can be designed to take greatest advantage of solar energy. This requires proper orientation on the site, windows that are designed to let in solar heat energy in the winter but not in the summer, and thermal masses to capture the energy for later release. Passive systems can include awnings, light shelves, screens and solar walls. These systems provide shade to reduce heat gain and still allow maximum opportunity to enhance daylighting.

<u>Utilize geothermal heating and cooling systems</u>- These systems work like heat pumps but leverage the stable average temperature of soil at depth to heat and cool thermal mass in the facility (e.g., floors) which then release that energy over time, often creating a more comfortable environment than forced air heating and cooling.

<u>Improve lighting energy efficiency</u>- Methods include daylighting which reduces the need for artificial light by letting the sun shine in through high windows, skylights, and reflective surfaces (50% reductions are possible with current technology.[3] Heat gains during the summer are can be reduced by using low emissivity glass, which lets in the light but blocks much of the heat. For the lighting needs that remain, high efficiency lighting technology can save substantially over more traditional lights. For example, EPA Energy Star partners averaged a 30-40% ROI on retrofits with high efficiency lighting.[4] The future will even be

"brighter" when photochromic windows become available on the market.

Utilize dehumidification- The use of chemical (or physical) absorption of water vapor to dehumidify air can reduce the latent cooling load in a building HVAC system. Specific benefits include: reduction in the energy (electricity) required to cool ventilation air, reduction of condensation and the growth of molds, improvement of the efficiency of refrigeration equipment by operating at higher evaporator temperatures, and reduction of the space required for central air handling equipment and ducts

Reduce peak energy use- Beyond total energy use, peak energy use can have a substantial impact on facility energy costs. Often, utilities price peak demand power at much higher marginal rates than off-peak rates, thus reductions in peak demand can generate substantial energy cost savings. The approaches already identified which reduce energy use overall will also reduce peak use. This higher level of cost savings must be considered when costing these approaches. However, beyond absolute energy reductions, additional energy cost savings can be reduced from load shifting. In other words, shifting the need for the energy from the late afternoon peak when rates are highest to the middle of the night when they are lowest. Methods for this include:

- Thermal energy storage techniques (store thermal energy in a thermal mass overnight for release during peak demand periods)
- On-site (distributed) energy generation capacity such fuel cell use (the natural gas used to run a fuel cell is generally not peak demand-priced, however if it were, a simple holding tank could avoid any such costs).

3.1.1.2 Water Efficiency Savings

Utilize low consumption fixtures- Low consumption fixtures can save not only on water costs (30% reductions possible with current technology[3]), but they also reduce the costs for associated pipes and pumps (smaller) and reduce sewer charges as well.

Utilize rainwater collection systems- Like so many sustainable design approaches, such systems used to be quite common. In the 1800s practically every building in New York City had such a system. In many buildings the old wood tanks still remain, although unused for decades. Theoretically, rainwater could be used as a source of potable water, but generally systems are limited to air conditioning, cooling towers, toilet systems, fire protection systems and landscape use. Not only does this save money purchasing the water, but also reduces stormwater run-off, a major concern for many municipalities. Reduction in the stormwater load can in turn reduce stormwater fees or taxes.

Utilize greywater systems- Water used once in the facility from sinks and toilet waste water or for cooling purposes can be reused for landscaping or recycled back into the building through the toilet systems . The waste water is treated on site and stored. This system requires a second piping system with a pump.

Utilize on-site wastewater treatment- Some relatively new technologies are making it potentially cost effective to treat water on-site using natural processes. Technologies exist today that in theory can support on-site wastewater treatment facilities. Onsite treatment would reduce sewerage fees and could allow facility to operate off the municipal sewer system altogether.

3.1.2 First Cost Portion of TCO

3.1.2.1 Mechanical Equipment Downsizing

As noted, many of the approaches specified above, in addition to lowering O & M costs, can also reduce the overall and/or the peak load for HVAC and other mechanical systems. Once these have been reduced, or eliminated, by design, either smaller, cheaper, or no systems at all may be required, thus lowering equipment first costs. Once mechanical systems are reduced, other related benefits can also accrue. Some of these are specified below.

Reduce or eliminate venting- Decreased HVAC requirements can lead to smaller sized ductwork or no ductwork at all. Smaller venting in a high rise can reduce the required height for floors. For example, by reducing duct size by 4 inches, and thus the height of each story, the Seafirst high-rise tower in Bellevue, Washington saved $68,000 in ductwork. But, more importantly, they got the 21st floor for free.[5]

Geothermal systems also eliminate the need for venting as they can be designed as radiant systems rather than forced air systems thus negating the need for venting.

Create more usable floor space- A reduced need for mechanical equipment also usually results in a reduction in non-productive floor space. The Seafirst tower noted above was able to save 400 SF of floor space on each floor which was worth over $250k/year in additional rent revenues.[5]

The use of displacement ventilation with raised access flooring and movable partitions reduces costly ductwork and provides cost effective office moves and remodels by reducing construction waste, facilitates ease of moving electrical and communication outlets and movable walls reduces construction cost for new materials.

3.1.2.2 Siting/Use of Brownfields

In some locations it may be advantageous to utilize environmentally-impaired property for development. Often this property can be acquired for prices below market by an amount great enough to pay for whatever site restoration is required. Further, there may be Federal and local government incentives in place (lower taxes, streamlined permitting, etc.) to encourage the development of these sites.

3.1.2.3 Insurance and Liability

While there is currently not much "hard" data supporting this area of potential benefit, the case can be made that insurance and/or liability costs are reduced for more sustainable buildings. For example, indoor air quality (IAQ) is a significant source of potential liability for building owners due to sick building syndrome (SBS). Indoor air quality is ranked by the EPA as the 5th greatest health threat to public health—and unhealthy air is found in 30% of new and renovated buildings.[6] Many sustainable buildings are designed to minimize the use of products with significant potential for generating indoor air pollution and they are also often designed with high ventilation and filtering rates. To put the potential costs of poor IAQ in perspective, several recent high profile IAQ lawsuit damages and repair costs have exceeded $20 million dollars, and the average settlement observed in one study of 44 such claims was for over $500k (or roughly 1% of the building construction values).[6]

3.1.2.4 Building Value

Reduced O & M rates for a facility can translate into an increased value for the building. Given two comparable buildings where one has a demonstrated lower O & M cost, a buyer should be willing to pay more for the higher performance building. This situation is analogous to comparing the capital value of a two bonds. While two bonds may each have a face value of $100, the bond paying an interest rate higher than the prevailing rate will be worth more than its face value, while the bond paying lower than the prevailing rate will be worth less than its face value. One source claims, based on a standard building market capitalization rate of 10%, that yearly savings on O & M costs for a building translated to a factor of 10 increase in the value of a building. Thus, a $100k/year savings in O & M would increase the value of a building by $1 million.[7]

3.1.2.5 Demolition and Clearing Costs

Design to accommodate specific site conditions can minimize the need for earth moving and other site preparatory activities, thus lowering first costs. Also, many rehabilitation projects have found ways to save and reuse major portions of existing buildings, thus saving on new materials and construction. Even when it is necessary to remove existing structures, where market conditions are favorable (inexpensive labor, high tipping fees, and an existing market for used building materials), disassembly rather than demolition followed by sale of certain used building materials can result in lower first costs. While labor costs are increased, the avoidance of landfill tipping fees and payment for salvaged materials are offsets, providing the potential for 50-98% net reductions in demolition costs.[8] Many permitting agencies are now requiring some level of recycling and salvage as a building permit condition for all new projects.

3.2 Tier 2- Productivity

Benefits at the Tier 2 level are relatively difficult to quantify, however, the existence of these benefits is increasingly being supported by research and case studies. Most importantly, is critical to note the potential magnitude of the Tier 2 impacts. Here again are some numbers to put the relative costs in perspective. The average annual lighting cost for American commercial buildings is $0.90/SF. These costs pale compared to the average cost of an office worker to occupy that space at $30/SF, and that number is based on an average hourly cost of $15.50/hour.[9] Of course information technology workers come at a much higher cost.

Some Tier 2 areas of potential benefit are discussed below.

3.2.1 Productivity Improvement (6 to 16% improvements)

We all know from personal experience that some places are just more pleasant to work in than others. The “why” behind this observation is the subject of numerous recent studies on environmental design. The quality of the air we breath, pleasant sounds and white noise, and pleasant smells are all considered potential causal agents, however, the single design feature with the most evidence linking it to improved productivity is the use of natural light in work areas. This design feature is known as "daylighting."

Studies are emerging which indicate a strong link between daylighting and various types of human performance (Table 2). For example, one recent study sponsored by Pacific Gas and Electric (PG&E) looked at student test scores for children in three different school districts across the US (Seattle, WA; Capistrano, CA; and Johnson County, NC). A comparison was made between the learning rate, as measured by standardized tests, between children attending classrooms with significant daylighting versus those that did not. The differences were striking. In the location with most significant findings (the Capistrano School District in California), students learning in effectively daylit classrooms progressed 20% faster in math and 26% faster in reading than those in artificially-lit classrooms. The study controlled for several potentially confounding factors such as socioeconomic class.[10]

Another recent study also sponsored by PG&E analyzes the effect of daylighting on retail sales. Again the results are compelling. A comparison was made between sample groups of otherwise identical stores, one sample set with daylighting (skylights) and the other without. The study found that the addition of daylighting improves sales by 40% over the non-daylit stores.[11] Sales improvements were determined based on gross store sales over an 18 month period. Similar findings were achieved at an experimental Walmart "eco-store." The test store was constructed in two "halfs." One based on a traditional design and the other based on a more sustainable design- including substantial dayighting. The per register sales rates on the daylit side of the store were found to be significantly higher. In addition, store personnel consistently asked to be assigned to work stations in the daylit side of the store.[12]

Improvements in productivity have been measured in several high performance building case studies as well. Productivity benefits that are claimed to derived from daylighting include the following (see Table 1):

- US Post Office- 6% increase in productivity
- Herman-Miller- Worker productivity and quality up by internal measures.
- West Bend Mutual Insurance- 16% productivity improvement.

Even skeptics may want to sit up and take notice of the potential for a building to improve the productivity of its occupants. Even if one does not readily accept that 16% improvement in productivity is reproducible at a given site, it should be recognized that even a very small increment of improvement can be extremely valuable. This is especially true for high cost knowledge workers in fields such as high-technology. To illustrate, Figure 1 below provides an analysis of the potential value of a 1% improvement in productivity for a knowledge-based firm. A 1% gain in productivity is worth $15 million over the useful life of a building – this is equal to the construction cost of the building (not considering the time value of money or inflation- which could be largely off-setting at 3-4% each). Even if one doubled the first cost of a facility through really pushing the envelope on design features, the owner would roughly break even based on only a 1% gain in productivity. A 6-16% gain would be "off the chart," and remember, it is possible for many of these benefits to accrue without significantly increasing first costs.

Figure 1

A) Average Campus Building Construction Cost		$80-150/SF
B) Average Campus Building Size		100,000 SF
C) Number of Employees per Average Building		500
D) Average Fully-burdened Salary per Employee		$100k
E) Useful Life of Building		30+ yrs.
F) Labor Costs per SF Over Useful Life	(C*D*E/B)	$15,000/SF
Labor Cost per SF vs Construction Cost per SF (F/A)		**100 to 1**
1% Productivity Improvement over 30 years (1%*C*D*E)		**$15 million**

3.2.2 Reduction in Absenteeism

A number organizations with activities in new, or redesigned high performance buildings, have observed significant decreases in absenteeism. The design element considered most likely to be responsible for these improvements is uncertain, but daylighting and indoor air quality are considered by many as the two most likely causes. Examples include the following (see Table 1):

- Lockheed Building 157- 15% reduction in absenteeism
- Verifone- 45% reduction in absenteeism
- ING Bank- 15% reduction in absenteeism

3.2.3 Reliability

High performance building features such as daylighting and passive solar design can mitigate the impacts of power outages. Power systems such as solar cells and fuel cells can potentially reduce or remove the facility from dependence on the power grid and reduce the likelihood of outages to near zero. While these considerations are often overlooked at the design stage, even one hour of productive labor saved during a power outage can be worth more than the cost of lighting an office all year long.[9]

3.3 Tier 3- Image

All of the benefits in the Tier 3 category are very difficult to quantify. But that doesn't make them irrelevant. Many corporations spend millions if not billions of dollars yearly to strengthen brand-image, improve positive press coverage, and to ensure favorable government treatment. It should be recognized, for example, that no solid body of empirical data exists which clearly and directly proves a cause and effect link between spending on marketing or other brand positioning activities and actual results in terms of sales or between spending on lobbyists and favorable government treatment. Exactly how many *additional* shoes did Nike sell because of the "Just do it" marketing campaign? Who knows? But I dare say that campaign was deemed a success. On the other hand, one might ask, how many *fewer* shoes did Nike sell due to unfavorable coverage on *20/20* and *Sixty Minutes* regarding labor and social responsibility practices by overseas subcontractors?

Despite the lack of such "hard" empirical evidence, there is a logical, common-sense linkage that is enough to convince most companies of the value of marketing and PR. So too should companies perceive the potential value of a more sustainable approach to facilities development. Customers, neighbors, and local governments alike will notice.

Potential Tier 3 benefits include the following.

1. Enhancement of Goodwill and Brand Image- Many corporations have effectively developed environmental sustainability as a key component of their corporate image and brand name. Leading examples include Ford, British Petroleum, Daimler Benz, Monsanto, Patagonia, The Body Shop, Smith and Hawken, to name just a few. There are many studies that indicate consumers will either pay more for green products or will chose the environmentally-preferable option when provided a choice. As Figure 3 indicates, buildings are responsible for a substantial share of the US environmental burden. Thus, this is a critical area of environmental performance for improvement by corporate America.

Figure 3
Environmental Burdens of Buildings[13]

Resource Use	% of Total	Pollution Emissions	% of Total
Raw Materials	30%	Atmospheric emissions	40%
Energy Use	42%	Water emissions	20%
Water Use	25%	Solid Waste	25%
Land (in SMSAs)	12%	Other releases	13%

2. Positive Press Coverage- A sustainable design project can be positioned to generate substantial positive press coverage. Such press coverage can be valuable to firms wishing to create or improve name recognition, to be seen as forward-looking, and to be perceived as bringing value to their community.

3. Community, Government, and Regulatory Support- Development projects which consider long-term sustainability issues are less likely to counter community resistance. Furthermore, local governments may provide incentives for sustainable development such as reduced permit fees or expedited permitting, which can be of great value to a project in a hurry, but at little or no cost to the government.

4.0 Lack of Incentive for Designers

As noted previously, understanding and measuring the economic benefits possible with high performance buildings is only half the battle. In order to encourage the types of economic benefits discussed in this paper, it is also necessary to align the incentives between the designer and the building owner/operator. Two potential scenarios which address this misalignment are noted below:

1. The facility owner/operator recognizes the inherent potential long-term savings possible from a sustainable design approach, and is thus willing to support a higher cost design effort. For example, this is the approach being taken by the City of Seattle. In fact, they are considering the possibility of floating public bonds to cover any incremental first costs. The bonds would then be repaid with facility O & M savings.

Or,

2. The designer somehow shares in the potential savings to be generated down the road from the additional "up-front" work through performance incentives for O & M, Tier 2, and possibly Tier 3 benefits realized over time in the commissioned building.

One proposed mechanism for scenario two, in the form of a new type of contractual arrangement, has been advanced by Eley Associates in San Francisco.[14]

5.0 Conclusion

In summary, a compelling case can be made for high performance buildings purely on the economics alone. Thus, like so many examples of good environmental strategy, most of the environmental benefits can come for "free." Because of this, facility owners should pursue high performance buildings whether they wish to be particularly "green" or not. To make this case, we must look at the full economics rather than limiting our decision-making to only a piece of the total economic "picture." To get to this point, those of us that wish to promote more sustainable building must seek to define the economic benefits within a framework that is consistent with existing decision-making terms, processes, and metrics. The tiered model of benefits presented in this paper is designed to provide such a framework. The tiered structure allows analysts to limit calculations to only those tiers of benefits that are likely to be accepted by decision-makers, while still identifying the existence of higher tiers of benefits. Furthermore, we must use that framework to align incentives between those that design buildings and facilities, those who build them, and those that own and operate them. The result will be a process where all three benefit-- in addition to the environment.

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ACKNOWLEDGEMENTS

Thanks to Skip Fresn, R.A. an architect in the CH2M HILL Design Center in Corvallis, Oregon for research support and technical review of this article and to Mark Velicer of the CH2M HILL Global Management and Information Systems Practice in Seattle for the development of Figures 1 and 2 illustrating the tiered economic benefit model.

Figure 1
Tiers of Economic Costs and Benefits

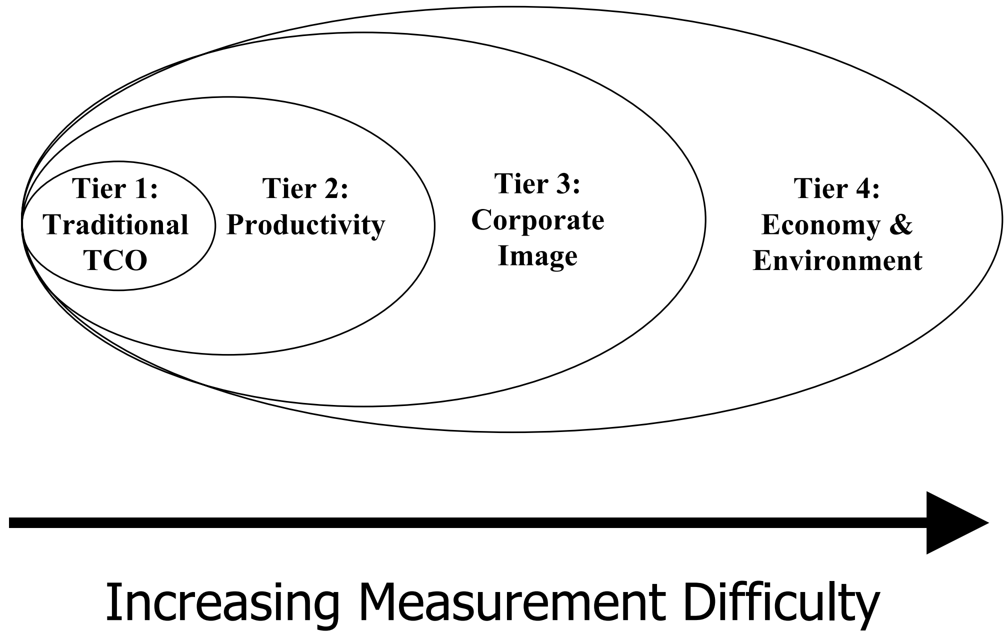

Figure 4
Potential to Add "Bottom-line Value Through High Performance Buildings

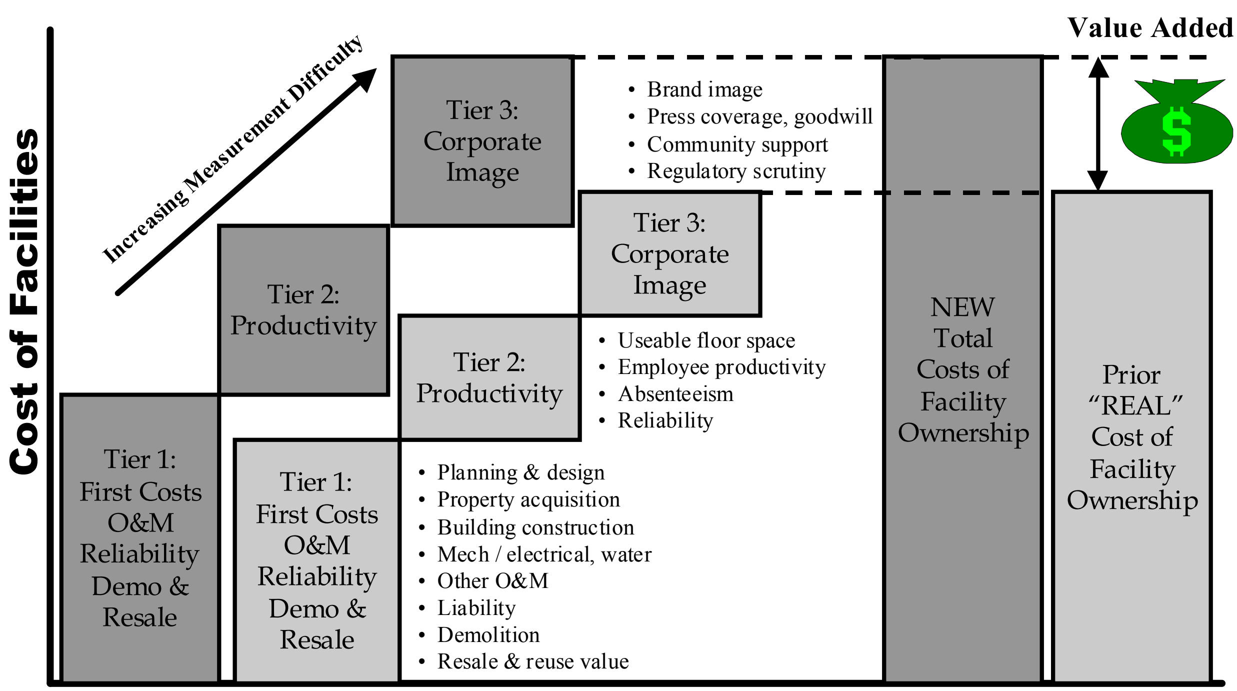

Table 1

Sustainable Design/ Green Building
Case Studies

Building/ Source	Location	Features	Benefits
Post Office Romm, “Lean and Clean Management,” Kodonsha International	Reno, NV	Daylighting Efficient lighting rehab Improved acoustics	Six-year payback Productivity Increase of 6%
AAS Building RMI CD ROM	Washington D.C.	Whole systems/integrated design Daylighting and efficient lighting Non-polluting HVAC and building materials Operable windows Space-saving design	50% reduction in energy use vs building code (90k btu/SF vs 183k conventional) 50% reduction in lighting energy vs comparable building 50% reduction in emissions
Audubon House RMI CD ROM	New York, NY	Whole systems/integrated design High % fresh air (30% more delivered) Daylighting Least toxic maintenance procedures	63% less energy than standard building (90000 btu/SF 75% reduction in electric lighting
Bering Office Building www.epa.gov/buildings/label/html/722.html	Houston, TX	Efficient lighting retrofit	Building operates at $1/SF less than market without any “tradeoffs”
Capital Circle Office Center RMI CD ROM	Tallahassee, FL	Whole systems/integrated design Green building materials Energy conserving design features	87% “space efficiency” vs 77% in older buildings Construction cost $60/SF vs $80/SF Average
Crestwood Corporate Center RMI CD ROM	Richmond, B.C.	Team approach integrating disciplines through all phases of design 50% more air exchanged Super-insulation Energy efficient lighting High performance commercial windows	50% of building is glazed while still reducing energy use by 50% vs ASHRAE and 60% vs neighboring buildings Air conditioning capacity reduced by 75% Payback on energy savings is 4.4 years

Table 1 **Sustainable Design/ Green Building** **Case Studies**			
Building/ Source	**Location**	**Features**	**Benefits**
Durst Building http:/ /www.smartoffice.com/ Smart_Business.html	New York, NY	Various energy efficiency initiatives Use of building materials that contribute to high quality indoor air	15-20% expected reduction in energy use vs current govt. standards
Foley Federal Square http://www.epa.gov/buildings/label/html/290.html	New York, NY	A building energy management system T-8 lighting fixtures Steam turbine centrifugal chillers, high efficiency motors, A variable air volume (VAV) air handling system.	Annual cost savings of $1.3 million compared to a building without such equipment and products
Four Times Square RMI CD ROM	New York, NY	First very large-scale commercial office building (skyscraper) "Green Building" Green building materials Super-insulation PV panels Env. & Energy-based performance compensation deal with tenant	Building completely pre-leased (not complete) Other benefits TBD

Table 1

Sustainable Design/ Green Building Case Studies

Building/ Source	Location	Features	Benefits
Frank J. Lausche State Office Building http://www.epa.gov/buildings/label/html/559.html	Cleveland, OH	Integrated engineering	42.4% reduction in electricity usage (kWh), a 38.3% reduction in kW demand, and an overall energy usage reduction of 32.1% (including electricity, gas, and district steam). An overall annual energy cost reduction of $338,500 (35.8%) at a cost of $1,806,350, the program will yield a simple payback of 5.34 years for the OBA.
Herman Miller Facility Articles by Members	Holland, MI	Daylighting Passive solar Natural Ventilation Constructed wetlands Electronic sensors	18% reduction in electric costs vs previous facility 65% reduction in water and sewer 7% reduction in natural gas use Worker productivity and quality have increased based on internal metrics Built at $49/SF
ING Bank RMI CD ROM	The Netherlands	Integrated design process Daylighting Passive solar Ventilation Water efficient landscaping	92% reduction in energy use vs comparable buildings Absenteeism down by 15%
Lockheed Building 157 RMI CD ROM	Sunnyvale, CA	Daylighting Energy efficient fixtures	50% reduction in energy use vs typical building of its size Absenteeism down by 15%
NREL Solar Research Facility http://www.nrel.gov/buildings/highperformance/projects/serf/serf.htm	Golden, CO	Daylighting, siting, and orientation Light shelves, overhangs, and fins Energy-efficient lighting Window shades controlled by photo sensor Direct and indirect evaporative cooling	40% reduced energy costs vs similar building meeting federal energy standards

Table 1

Sustainable Design/ Green Building Case Studies

Building/ Source	Location	Features	Benefits
		Laboratory exhaust heat recovery High-efficiency motors with variable frequency drives Up-sized cooling tower Selective glazing Building designed using simulation to optimize energy features.	
Queens Building RMI CD ROM	Leicester	Whole systems design Passive ventilation Operative windows (60% of glazing) Thermal mass	50% reduction in energy use vs standard construction Mechanicals cost 24% of total cost vs 35-40% std.
Quest Tower www.epa.gov/buildings/ label/html/qwest.html	Denver, CO	Installation of a 600-ton flat plate heat exchanger that allows the property to utilize tower free cooling up to 70-degree outdoor temperatures Strategic operation of the central plant systems to maximize energy savings without jeopardizing tenant comfort conditions using real time energy consumption and demand data from Public Service Company Power Manager software. Repair and calibration of all building system components Installation of T-8/electronic ballast lighting during tenant finish construction. Interlocked space heating and cooling controls that prevent simultaneous operations and cut off heat when interior space conditions are satisfied. Maintenance procedures to maximize the	Cumulative savings of $1,835,000 in five years

Table 1

Sustainable Design/ Green Building Case Studies

Building/ Source	Location	Features	Benefits
		integrity of the building envelope	
Ridgehaven Ridgehaven Green Building Demonstration Project 9601 Ridgehaven Court San Diego, CA 92123	San Diego, CA	Renovation project Various green design elements Life-cycle financial analysis employed	47% reduction in energy use vs CA Title 24 compliant building
RMI Headquarters RMI CD ROM	Snowmass, CO	Super-insulation Super-windows Passive solar PV cells	90% reduction in electricity use 99% savings in water and heating costs $1.50/SF marginal increase in building costs paid back in 10 months (with 1983 technology)
San Diego Environmental Services Dept. Building Sustainable Building Technical Manual	San Diego, CA	Renovation Efficient mechanicals, lighting, appliances Computer controlled systems	Operating cost savings $0.90/sf vs typical similar building 60% reduction in energy 65 vs CA Title 24 standard 4-year payback (without rebates from utility)
SC Johnson RMI CD ROM		Daylighting Super-insulation Heat recovery system Efficient mechanical system Personal climate controls	Annual energy costs $0.46/SF vs existing facility at $1.51/SF and national average of $2.20/SF
Seventh Generation Systems RMI CD ROM	Friday Harbor, WA	High performance window Super-insulation Solar space and water heating PV system	82% reduction in energy use vs code Sewer and water reduction is 69% vs comparable facility

Table 1

Sustainable Design/ Green Building
Case Studies

Building/ Source	Location	Features	Benefits
		Un-interruptible power supply	
Southern California Gas RMI CD ROM	Southern CA	80% recycled materials Daylighting Indoor air quality sensors Interface carpet lease Water efficient landscaping	45% reduction in energy use vs CA Title 24 requirements
St. Benedicts Child Care Center http://www.usgbc.org/resource/	Louisville, KN	Energy-efficient lighting, T-8 fluorescent fixtures Daylighting Passive solar Radiant floor heating Increased insulation in walls, roof, 2nd floor High-efficiency windows	46% reduction in energy use vs base case (38% without daylighting)
West Bend Mutual Insurance City of Seattle - 4 pg overview	West Bend, IN	Daylighting Superinsulation Efficient HVAC Individual controls over temp, air flow and White noise	40% reduction in annual electric costs ($126k/yr) 16% increase in productivity Temp complaints dropped (40/day to 2/week - est. cost $25 each) First costs reduced from $125/SF to $90/SF ($5,250k savings)
Verifone (rehab) RMI CD ROM	Costa Mesa, CA	Whole Systems "Redesign" Daylighting Non-toxic Material High volume air exchange (26-39cfm/pp of outside air)	45% reduction in absenteeism 65-75% energy savings (payback in 7.5 years)

Table 2

Sustainable Design/Green Buildings
Studies Supporting Performance Improvements

Technique/Location	Benefit/Impact	Study Methodology	Source
Daylighting Capestrano, CA Fort Lewis, CO Seattle WA **Operable Windows** Capistrano, CA	**Test Score Improvements** 20% Math 26% Reading 6-15% Math 7-13% Reading 7% Math and Reading	Compare test scores for students with most daylighting vs. those with less—same for operable windows.	PG & E Daylighting Initiative Study. Daylighting in Schools, by Heschong Mahone Group, Fair Oaks, CA 8/20/99
Daylighting Wal-Mart Stores Lawrence, KA Moore, OK Los Angeles, CA	• "Significant" increase in per register sales • Employee satisfaction greater in daylighted area.	Daylighting installed in 1/2 of store—not in other half.	Tomorrow Magazine. Nov-Dec 1999, pg. 18 Natural Capitalism. 1999, pg. 89
Daylighting	31 to 49% higher sales in comparable stores with skylights. (average: 40%).	Chain retailer with 108 nearly identical stores—skylighted stores analyzed vs. non-skylighted stores.	PG & E Daylighting Initiative Study. "Skylighting and Retail Sales," by Heschong Mahone Group, Fair Oaks, CA. 8/20/99