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Sustainable Buildings and its Positive Impacts

Green (LEED) Building and Financial Benefits

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List of Acronyms

USGBC	United State Green Building Council
TOU	Time of Use
EPA	Environmental Protection Agency
A&E	Architectural and Engineering
NPV	Net Present Value
IEQ	Indoor Environmental Impact
MTC	Massachusetts Technical Collaborative

1- Introduction

“Green” or “sustainable” buildings use key resources like energy, water, materials, and land more efficiently than buildings that are just built to code. With more natural light and better air quality, green buildings typically contribute to improved employee and student health, comfort, and productivity. The United States Green Building Council (USGBC), a national non-profit membership organization, developed the Leadership in Energy and Environmental Design (LEED) SystemTM to provide a guideline and rating system for green buildings.

It is generally recognized that buildings consume a large portion of water, wood, energy, and other resources used in the economy. For example, US buildings alone are responsible for more CO₂ emissions than those of any other entire country in the world except China (Kinzey et al). If building green is cost effective, a broad shift to green construction offers a potentially promising way to help address a range of challenges facing urban cities, including:

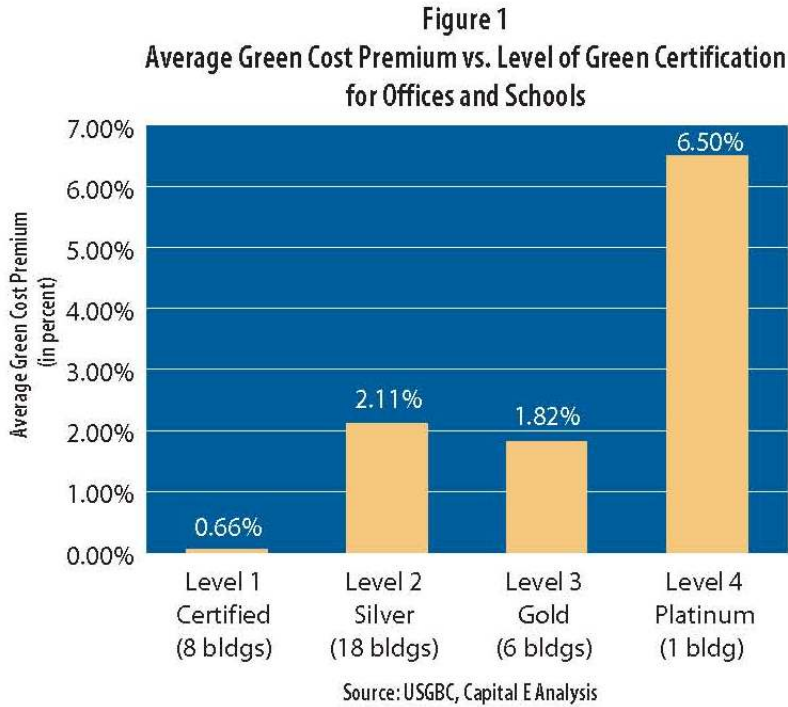
- Address growing costs of transmission and distribution congestion. The growth of Time of Use rates (TOU) by municipal utilities, and the creation of congestion pricing in the form of location marginal pricing allows building owners to capture some of the benefits associated with lower overall and lower peak energy use in green buildings
- Reduce or slow rise in electricity and gas prices through expanded green construction and building retrofits and reduced energy demand
- Help cut pollution from fossil fuels including fine particulates in urban areas
- Help municipalities meet EPA mandated emissions reductions targets
- Improve quality of educational environment and improve school test scores
- Enhance competitiveness by providing work and living environments characterized by superior health and comfort and work environments

2- Description

Green buildings are commonly perceived to be a lot more expensive than conventional buildings and often not worth the extra cost. For example, an early 2003 article in the New York Times was entitled “Not Building Green Is Called a Matter of Economics.”

In order to determine the cost of building green compared to conventional design, several dozen building representatives and architects were contacted to secure the cost of 33 green buildings from across the United States compared to conventional designs for those same buildings. The average premium for these green buildings is slightly less than 2%, or \$3-5/ft², substantially lower than is commonly perceived (See Figure 1). The

majority of this cost is due to the increased architectural and engineering (A&E) design time, modeling costs and time necessary to integrate sustainable building practices into projects. Generally, the earlier green building features are incorporated into the design process, the lower the cost.



3- General Analysis

3.1 GREEN BUILDINGS FINANCIAL BENEFITS

Green Buildings provide financial benefits that conventional buildings do not. These benefits include energy and water savings, reduced waste, improved indoor environmental quality, greater employee comfort/productivity, reduced employee health costs and lower operations and maintenance costs. This paper will focus on two of these benefits: lower energy costs, and health and productivity benefits.

3.1.1 Energy

Energy is a substantial and widely recognized cost of building operations that can be reduced through energy efficiency and related measures that are part of green building design. The average annual cost of energy in buildings generally is approximately \$2.00/ft². On average, green buildings use 30% less energy than conventional buildings—a reduction, for a 100,000 ft² state office building, worth \$60,000 per year, with a 20-year present value of expected energy savings at a 5% real discount rate worth about three quarters of a million dollars.

A detailed review of 60 LEED rated buildings, demonstrates that green buildings, when compared to conventional buildings are:

- On average 25-30% more energy efficient
- Characterized by even lower electricity peak consumption
- More likely to generate renewable energy on-site
- More likely to purchase grid power generated from renewable energy sources (green power and/or tradable renewable certificates)

Figure 2
Reduced Energy Use in Green Buildings as Compared with Conventional Buildings

	Certified	Silver	Gold	Average
Energy Efficiency (above standard code)	18%	30%	37%	28%
On-Site Renewable Energy	0%	0%	4%	2%
Green Power	10%	0%	7%	6%
Total	28%	30%	48%	36%

Source: USGBC, Capital E Analysis

Green building energy savings primarily come from reduced electricity purchases and secondarily from reduced peak energy demand. On average, green buildings are 28% more efficient than conventional buildings and generate 2% of their power on-site from photovoltaic (PV) (see Figure 2). The financial benefits of 30% reduced consumption at an electricity price of \$0.08/kWh are about \$0.30/ft²/yr, with a 20-year NPV of over \$5/ft², equal to or more than the average additional cost associated with building green.



The Genzyme Corporation's recently completed office in Cambridge is a world-class example of green building construction, including advanced day lighting and thermal technologies. In addition to a photovoltaic installation funded by MTC, one of the most prominent features is a combined heliostat and reflective panel system designed to channel daylight deep into the 8-story building.

The environmental and health costs associated with air pollution caused by non-renewable electric power generation and on-site fossil fuel use are generally externalized (not considered) when making investment decisions.

3.1.2 Productivity and health

There is growing recognition of the large health and productivity costs imposed by poor indoor environmental quality (IEQ) in commercial buildings—estimated variously at up to hundreds of billions of dollars per year. This is not surprising as people spend 90% of their time indoors, and the concentration of pollutants indoors is typically higher than outdoors, sometimes by as much as 10 or even 100 times (USEPA).

The relationship between worker comfort/productivity and building design/operation is complicated. There are thousands of studies, reports and articles on the subject that find significantly reduced illness symptoms, reduced absenteeism and increases in perceived productivity over workers in a group that lacked these features (Judith Heerwagen). For example, two studies of over 11,000 workers in 107 European buildings analyzed the health effect of worker-controlled temperature and ventilation. The Report relies in large part on recent meta-studies that have screened tens or hundreds of other studies and have evaluated and synthesized their findings.

Following are some relevant attributes common in green buildings that promote healthier work environments:

- On average 25-30% more energy efficient
- Much lower source emissions from measures such as better siting (e.g., avoiding locating air intakes next to outlets, such as parking garages, and avoiding recirculation), and better building material source controls (e.g., required attention to storage). Certified and Silver level green buildings achieved 55% and Gold level LEED buildings achieved 88% of possible LEED credits for use of the following (Capital E. analysis of USGBC): less toxic materials, low-emitting adhesives & sealants, paints, carpets, and composite woods, and indoor chemical & pollutant source control.
- Significantly better lighting quality including: more day lighting (half of 21 LEED green buildings reviewed provide day lighting to at least 75% of building space) (Capital E. analysis of USGBC), better daylight harvesting and use of shading, greater occupancy control over light levels and less glare
- Generally improved thermal comfort and better ventilation—especially in buildings that use under floor air for space conditioning
- Commissioning, use of measurement and verification, and CO₂ monitoring to ensure better performance of systems such as ventilation, heating and air conditioning

Measuring the exact financial impact of healthier, more comfortable and greener buildings is difficult. The costs of poor indoor environmental and air quality—including higher absenteeism and increased respiratory ailments, allergies and asthma—are hard to measure and have generally been “hidden” in sick days, lower productivity, unemployment insurance and medical costs.

However, four of the attributes associated with green building design—increased ventilation control; increased temperature control, increased lighting control and increased day lighting—have been positively and significantly correlated with increased productivity. Increases in tenant control over ventilation, temperature and lighting each provide measured benefits from 0.5% up to 34%, with average measured workforce productivity gains of 7.1% with lighting control, 1.8% with ventilation control, and 1.2% with thermal control. Additionally, significant measured improvements have been found with increased day lighting.

There are also quantifiable green building gains in attracting and retaining a committed workforce—an aspect beyond the scope of the Report. Attracting and retaining the best employees can be linked to the quality of benefits that workers receive, including the physical, environmental and technological workplace. Green buildings are designed to be healthier and more enjoyable working environments. Workplace qualities that improve the environment of knowledge workers may also reduce stress and lead to longer lives for multi-disciplinary teams.

LEED rated buildings all address some combination of measures that help reduce the pollutants that cause sickness and increase health care costs; improve quality of lighting and increase use of day lighting; and increase tenant control and comfort. LEED Green buildings consistently include a range of material, design and operation measures that directly improve human health and productivity. Gold and Platinum level LEED buildings are more comprehensive in applying IEQ-related measures and therefore should be viewed as providing larger productivity and health benefits than Certified or Silver level green buildings.

Given the studies and data reviewed above, the Report recommends attributing a 1% productivity and health gain to Certified and Silver level buildings and a 1.5% gain to Gold and Platinum level buildings. These percentages are at the low end of the range of productivity gains for each of the individual specific building measures— ventilation, thermal control, light control and day lighting—analyzed above. They are consistent with or well below the range of additional studies reviewed in the Report.

A 1% increase in productivity (equal to about 5 minutes per working day) is equal to \$600 to \$700 per employee per year, or \$3/ft² per year. A 1.5% increase in productivity (or a little over 7 minutes each working day) is equal to about \$1000 per year, or \$4 to \$5/ft² per year. Over 20 years and at a 5% real discount rate, the present value of the

productivity benefits is about \$35/ft² for Certified and Silver level buildings, and \$55/ft² for Gold and Platinum level buildings. The relatively large impact of productivity and health gains reflects the fact that the direct and indirect cost of employees is far larger than the cost of construction or energy. Consequently, even small changes in productivity and health translate into large financial benefits. Assuming a longer building operational life, such as 30 or 40 years, would result in substantially larger benefits.

4- Actualization - Case Study

4.1 Green Buildings in Massachusetts

Massachusetts is a leading state in the rapidly growing green building movement. Buildings consume 70% of the nation's electricity and a large part of the materials, water and waste and used and generated in our economy. Buildings have traditionally been viewed as a relatively static sector of the economy experiencing relatively little change in the technology or resources consumption patterns. To date there has been a widespread perception that green buildings thought more attractive from environmental and health perspectives—are substantially more costly than conventional design and may not be justified from a cost benefits perspective. This perception has been the single largest obstacle to the more widespread adoption of green design.

Massachusetts already has established national leadership in green buildings, including achieving the first gold rated federal building (at EPA's Chelmsford Lab), and is well positioned to build on this. Doing so will involve developing policies that allow green buildings to capture the financial value of benefits associated with green design. Although this issue is beyond the scope of this paper, two disparate examples are worth noting:

1. Accelerated permission for the Manulife Financial Headquarters building in South Boston resulting from the perceived benefits associated from its green design suggests one way to make these links more clearly.
2. An expected shift from zonal to nodal pricing system for load and generation pricing is a step towards allowing more accurate mapping of real cost into price signals that might allow green buildings to better capture the financial benefits resulting from green construction.

It is also worth noting that:

- Nearly one-fifth of Massachusetts' population spend their day inside schools
- Only 43% of high-volume chemicals have been tested for potential human

toxicity, and only 7% have been tested for their effect on children’s development (Philip Landrigan et al)

- Asthma is the leading cause of admission of urban children into hospitals and the leading cause of days absent from school

Green building improvements—especially for new buildings—appear to be very cost effective compared with other available measures to enhance student performance. Under the recently adopted Federal Education Bill, schools and states stand to lose billions of dollars in federal funding if students do not perform well on annual standardized tests. School and university systems should consider adopting whole building green design at the LEED Gold level requirement in new school design and school retrofits.

5- Discussion

Green Buildings provide financial benefits that conventional buildings do not. As indicated in Figure 3 below, it has been concluded that financial benefits of green design are between \$50 and \$70 per square foot in a LEED building, over 10 times the additional cost associated with building green. The financial benefits are in lower energy, waste and water costs, lower environmental and emissions costs, and lower operational and maintenance costs and increased productivity and health.

6- General Recommendation

The benefits of building green include cost savings from reduced energy, water, and waste; lower operations and maintenance costs; and enhanced occupant productivity and health. As Figure 3 indicates, the total financial benefits of green buildings are over ten times the average initial investment required to design and construct a green building. Despite data limitations and the need for additional research in various areas, the data demonstrates that building green is cost-effective today, particularly for those projects which start “green” design early in the process.

Figure 3
Financial Benefits of Green Buildings
Summary of Findings (per ft²)

Category	20-year Net Present Value
Energy Savings	\$5.80
Emissions Savings	\$1.20
Water Savings	\$0.50
Operations and Maintenance Savings	\$8.50
Productivity and Health Benefits	\$36.90 to \$55.30
Subtotal	\$52.90 to \$71.30
Average Extra Cost of Building Green	(-3.00 to -\$5.00)
Total 20-year Net Benefit	\$50 to \$65

Source: Capital E Analysis

7- Conclusion

Green buildings are commonly perceived to be a lot more expensive than conventional buildings and often not worth the extra cost. For example, an early 2003 article in the New York Times was entitled “Not Building Green Is Called a Matter of Economics.”

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