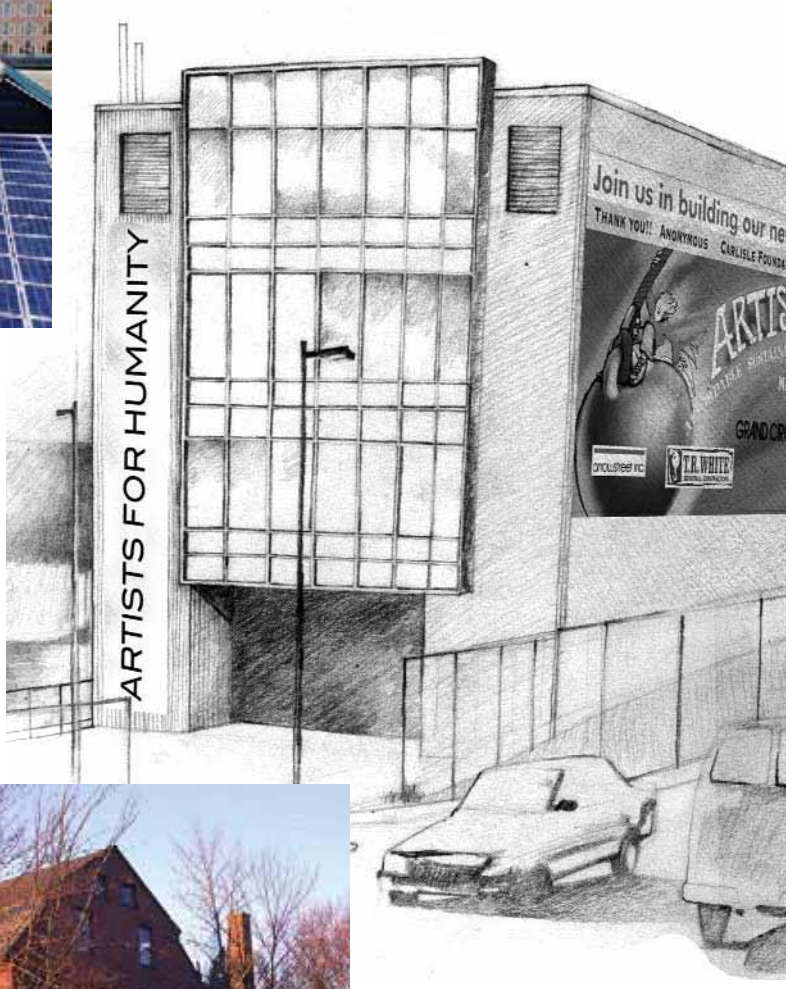
Green Building Costs and Financial Benefits

by Gregory H. Kats



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The Massachusetts Technology Collaborative is the state's development agency for renewable energy and the innovation economy. The agency administers the Renewable Energy Trust, which is maximizing the benefits of clean energy and helping to create jobs for the Commonwealth by stimulating new supply and demand for green power. The Trust was created in 1998 through the electric restructuring law and is funded through a monthly surcharge on electric utility bills. For more information, please visit the agency's website www.masstech.org.

Captions for cover photos (top to bottom)

The J.F. Williams Federal Building in Boston includes 30 kW of solar photovoltaics and a 75 kW cogeneration system. Through an MTC grant, a data acquisition system has been installed at the site to monitor the production and savings of these systems.

Artists for Humanity is building a new facility in the Fort Point Channel district of Boston to house its arts education programs. The building has been designed to reduce energy use by 65% and to include significant daylighting and other green building features. Up to 100% of remaining energy needs will be met by the installation of 45 kW of solar photovoltaics funded by MTC.

In its redevelopment of an historic mill building as a mixed-use office and commercial facility, Alternatives Unlimited has focused on the design of green building and energy efficiency features that will best meet occupant needs. The capstone of this project will be the restoration of a hydropower system in Whitinsville's Mumford River adjacent to the mill to provide the facility's electricity.

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Greg Kats, Capital E

Introduction

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 used and generated in our economy. Buildings have traditionally been viewed as a relatively static sector of the economy experiencing relatively little change in technology or resource consumption patterns. To date there has been a widespread perception that green buildings—though more attractive from an environmental and health perspective—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.

The Woods Hole Research Center received a total of $500,000 in MTC awards to install 26.4 kW of solar photovoltaics and a 100 kW wind turbine at the site of its new headquarters. Combined with innovative energy efficiency measures and high-performance design, these renewables will help Woods Hole achieve its goal of a "Zero Energy" facility, producing more energy than it consumes. Pictured here, the Ordway Building.

This paper reviews a major recent report on the issue of green building costs benefits, "The Costs and Benefits of Green Buildings," Kats[1] et al., October 2003 [2] (the Report). Led by Capital E, the Report was prepared in partnership with the US Green Building Council and California's Sustainable Building Task Force for 40+ California state agencies.

What are green buildings?

"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) System™ 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 CO_2. emissions than those of any other entire country in the world except China.[3] 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 Massachusetts, including:

- Address growing costs of transmission and distribution congestion. The growth of Time of Use rates (TOU) by Massachusetts utilities, and the creation of congestion pricing in the form of locational marginal pricing [4] allows building owners to capture some of the benefits associated with lower overall and lower peak energy use in green buildings

1 The author is founding Principal of Capital E, a national clean technology deployment and strategy firm. Mr. Kats served from 1996 to 2001as the Director of Financing for the $1.1 billion dollar Office of Energy Efficiency and Renewable Energy at the US Department of Energy - the largest clean technology R&D and deployment program in the US. He is Chair of the Energy And Atmosphere Technical Advisory Group for LEED and serves on the LEED Steering Committee.

2 "The Costs and Benefits of Green Buildings", A Report to California's Sustainable Building Task Force, October 20003. Principal author Greg Kats, For full text and summary slides see www.cap-e.com

3 Kinzey et al., "The Federal Buildings Research and Development Program: A Sharp Tool for Climate Policy," 2002 ACEEE proceedings, Section 9.21.

4 see: http://www.iso-ne.com/iso_news/SMD_Reference_Guide/02_Locational_Marginal_Pricing_(LMP).pdf

- Reduce or slow rise in electricity and gas prices through expanded green construction and building retrofits and reduced energy demand [5]
- Help cut pollution from fossil fuels (Massachusetts fuel mix includes 28% coal as of 1999 - US DOE) including fine particulates in urban areas
- Help Massachusetts 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

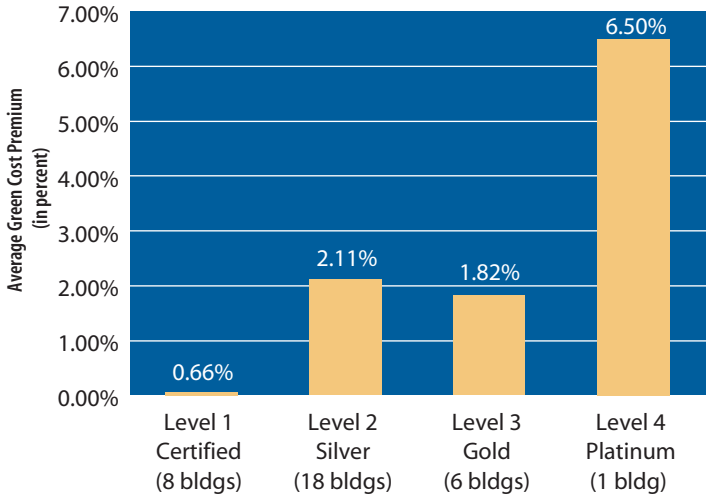
How much more do green buildings cost?

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/ft^2, 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.

The cost of green design has dropped in the last few years as the number of green buildings has risen. The trend of declining costs associated with increased experience in green building construction has been experienced in Pennsylvania, as well as in Portland and Seattle. Portland's three reported and completed LEED Silver buildings were finished in 1995, 1997, and 2000. They incurred cost premiums of 2%, 1% and 0% respectively. Seattle has seen the cost of LEED Silver buildings drop from 3-4% several years ago to 1-2% today.

Figure 1
Average Green Cost Premium vs. Level of Green Certification for Offices and Schools



Source: USGBC, Capital E Analysis

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.

5 See for example, "Impacts of Energy Efficiency and Renewable Energy on Natural Gas Markets", Elliott et al., ACEEE, Sept, 2003. See: http://aceee.org

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 Massachusetts buildings is approximately $2.00/ft^2. On average, green buildings use 30% less energy than conventional buildings—a reduction, for a 100,000 ft^2 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 photovoltaics (PV). (See Figure 2.) The financial benefits of 30% reduced consumption at an electricity price of $0.08/kWh are about $0.30/ft^2/yr, with a 20-year NPV of over $5/ft^2, 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 daylighting 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. The larger Report this paper draws from quantifies two of these benefits: the value of peak power reduction and the value of emissions reductions associated with the energy strategies integrated into green building design. The Report calculates these additional financial benefits are equal to about one third of that provided by energy savings alone.

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.[6]

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.[7] 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:[8] less toxic materials, low-emitting adhesives & sealants, paints, carpets, and composite woods, and indoor chemical & pollutant source control.

Urban Edge is developing a pioneering example of green building opportunities in affordable housing. Through an MTC grant, the non-profit will install 63 kW of solar photovoltaics at the new Egleston Crossing development in Jamaica Plain and Roxbury. This installation, in combination with multiple energy efficiency measures, will reduce the project's electricity needs by 50%.

- Significantly better lighting quality including: more daylighting (half of 21 LEED green buildings reviewed provide daylighting to at least 75% of building space[9]), 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 underfloor air for space conditioning
- Commissioning, use of measurement and verification, and CO_2 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

6 US Environmental Protection Agency, "Indoor Air Quality," January 6, 2003. Available at: http://www.epa.gov/iaq/.

7 Judith Heerwagen, "Sustainable Design Can Be an Asset to the Bottom Line - expanded internet edition," Environmental Design & Construction, Posted 07/15/02. Available at: http://www.edcmag.com/CDA/ArticleInformation/features/BNP__Features__Item/0,4120,80724,00.html.

8 Capital E analysis of USGBC data (based on analysis of points actually achieved in building performance data submitted to USGBC), November and December 2002. For more detail on achievable reductions from some of these indoor emissions sources, please see: Hodgson AT. "Common Indoor Sources of Volatile Organic Compounds: Emissions Rates and Techniques for Reducing Consumer Exposures." University of California, Lawrence Berkeley National Laboratory. 1999.

Prepared for California Air Resources Board.

Available at: http://www.arb.ca.gov/research/apr/past/indoor.htm#Toxic%20Air%20Contaminants.

9 Capital E analysis of USGBC data, November and December 2002.

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 daylighting—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 daylighting.

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 daylighting; 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 daylighting—analyzed above. They are consistent with or well below the range of additional studies reviewed in the Report.

The Blackstone Valley Vocational Regional School District is planning an ambitious 80,000 square foot addition to accommodate four new vocational programs, and will renovate the existing building which has some systems that date back to the 1960's. Daylighting will be accomplished in this project by using light tube technology, which will save over 500 kW a year. Other efficiency measures include efficient air conditioning equipment and variable speed drives for the air handling unit. The school will also incorporate photovoltaic panels mounted on the roof and a solar thermal domestic water preheating system.

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/ft^2 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/ft^2 per year. Over 20 years and at a 5% real discount rate, the present value of the productivity benefits is about $35/ft^2 for Certified and Silver level buildings, and $55/ft^2 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.

It is 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 [10]
- Asthma is the leading cause of admission of urban children into hospitals and the leading cause of days absent from school [11]

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 or corresponding MASS-CHP scoring as a standard requirement in new school design and school retrofits.

The MITRE Corporation is developing a new state-of-the-art campus center at its Bedford facility to be built according to a comprehensive energy plan and green building standards. With assistance from an MTC grant, the project will incorporate 16.5 kW of rooftop photovoltaics and 12.5 kW of advanced semi-transparent solar photovoltaic panes installed on a covered walkway.

10 Philip Landrigan et al, "Environmental Pollutants and Disease in American Children: Estimates of morbidity, Mortality, and Costs of Lead Poisoning, Asthma, Cancer and Developmental Disabilities," Environmental Health Perspectives, Volume 110, Number 7, July 2002.

Available at: http://ehpnet1.niehs.nih.gov/docs/2002/110p721-728landrigan/abstract.html.

11 Ibid.

Overall costs and financial benefits

Green Buildings provide financial benefits that conventional buildings do not. As indicated in Figure 3 below, the Report 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.

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:

- Accelerated permissioning for the Manulife Financial Headquarters building in South Boston [12] resulting from the perceived benefits associated from its green design suggests one way to make these links more clearly.
- 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.

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 ft^2)

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

12 See: http://www.bankerandtradesman.com/pub/4_91/commercial/185123-1.html

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