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On the Incremental Costs of Greener Buildings

Michael Edwin Canes

Energy and Environment Group, Logistics Management Institute (LMI), McLean, Virginia, USA

Email address

mcanes@lmi.org

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Abstract: Analysts have examined the economics of high-performance or "green" buildings. The literature indicates that such buildings obtain higher rentals and sales prices than comparable "standard" buildings. Fewer analyses examine the incremental costs of investing in green versus standard buildings. Even fewer examine the cost to move beyond one green standard to another. This paper estimates the costs of achieving ASHRAE 189.1 versus LEED standards for four standalone US government buildings. It isolates and costs the added requirements of 189.1 and compares the total to the buildings' construction costs. Because little if any information exists on the incremental costs of investing to attain a greener standard, the paper makes a unique contribution.

Keywords: Green Buildings, Green Building Standards, Incremental Costs of Green Standards

1. Introduction

Over the past several years, analysts have taken a strong interest in the economics of "high-performance" or "green" buildings. Such buildings are of particular interest because they reduce requirements for energy and water relative to standard buildings and thus help to preserve scarce resources and attenuate environmental challenges. Analysts are also interested in understanding behavior in buildings markets—for example, whether renters or purchasers will pay more for green buildings and the incremental costs of such buildings.

Buildings use about a third of the electricity and almost 20 percent of all energy consumed in the United States. Much of the electricity is supplied by fossil fuels, whose combustion produces a number of emissions, including greenhouse gases. In addition, office buildings consume an estimated 20–35 gallons of water per day, per person [2]. As of 2014 there were 120 million service industry workers in the United States [21],[1] indicating that water consumption in office buildings is several billions of gallons per day.

A good deal of previous research has examined sources of incremental value accruing to green buildings and the magnitude of that value. Fewer authors, however, have examined incremental costs. Such information is difficult to come by; buildings tend to be unique with respect to location and makeup, and cost estimates often involve counterfactuals—that is, what it would have cost to build green had the building not been constructed in a standard way, or vice versa. There appears to be even less information on the incremental costs of building to one green standard versus another—for example, LEED Platinum versus LEED Gold.[2]

This paper offers information from a limited set of buildings for which the incremental cost of building to one green standard versus another was estimated. The incremental costs pertain in particular to the achievement of the ASHRAE 189.1 standard[3] versus LEED Silver, Gold, or Platinum. The incremental costs were calculated for four buildings, all owned by the U.S. Air Force (USAF). In this paper, I describe the method used to derive the cost estimates and what they show. The results separate out the costs of

1 There were additional workers in manufacturing and agriculture, all of whom consumed water on a daily basis, but the subject here is office buildings.

2 LEED is a certification system offered by the U.S. Green Building Council (USGBC) and stands for Leadership in Energy and Environmental Design. There are four LEED categories—Certified, Silver, Gold, and Platinum—each a more rigorous standard than the previous.

3 ASHRAE stands for the American Society of Heating, Refrigerating and Air-Conditioning Engineers. The society, in conjunction with the American National Standards Institute, the Illuminating Engineering Society (IES), and the USGBC, issued building standard 90.7 in 2007. Four years later, in 2011, ASHRAE, the IES, and the USGBC issued standard 189.1. The latter standard intended to achieve significantly greater energy savings than 90.1 as well as many other goals, such as recycling of building materials and use of renewable energy.

providing renewable energy at the building sites from other investments necessary to achieve the ASHRAE 189.1 standard. Excluding the renewables the results indicate, with one unusual exception, that the incremental costs are relatively low, in the range of 0.3–1.1 percent. Further, with updated data on the costs of installing solar panels, the results show that the full incremental costs of ASHRAE 189.1 versus LEED standards for the four buildings range between 0.8 and 3.1 percent.

The paper proceeds as follows. The next section briefly summarizes some issues concerning green buildings that have been addressed in the literature, including their incremental costs. I then describe the approach taken to estimate the incremental costs of building to the ASHRAE 189.1 standard versus LEED Silver, Gold, or Platinum at the four USAF properties. The following section presents the incremental cost estimates, with and without the cost of renewables included, and two brief final sections discuss the results and offer conclusions and implications.

2. Background

Statistically, it has been well established that green buildings offer owners and renters various benefits. These include saved energy and water [6, 15], better worker performance [14, 1], and better use of space [23]. The monetary values of these benefit streams have been examined by comparing rents, occupancy, and sales value of certified green buildings with standard buildings after correcting for other factors [see, e.g., 3, 4, and 7]. Other research has shown that increased rents and sales prices in green-certified buildings exceed the value of reduced energy and water expenses [18] and that even without certification, office buildings constructed to green standards obtain higher rents and sales prices [16]. There also has been discussion of why increased green building sales prices exceed increased rental income,[4] the extent to which green building certification resolves information differences between renters and owners,[5] and whether investments to achieve green certification help to resolve externality issues [e.g., 17 and 12].[6]

Although enhanced income and sales prices alone do not convey whether it pays to invest in green buildings, rising numbers of green certified buildings over time suggest that building investors think such certification is economically worthwhile. Figure 1, from the U.S. Environmental Protection Agency [22], indicates cumulative numbers of certified Energy Star buildings between 2001 and 2015. These numbers show roughly a 25-fold increase during this time period.

Similarly, the USGBC has published data on annual numbers of newly LEED-registered and -certified buildings between the years 2000 and 2016 [19]. These data indicate steady growth of such buildings over the period. Between 2000 and 2006, for example, LEED certified 715 building projects (approximately 9 per month over this period) while over the next two years, 2007 and 2008, an additional 1,500 projects were certified (63 per month). According to the USGBC, as of 2016, there were 38,600 certified LEED commercial projects in the United States.[7] Although many of these involved recertification, the number suggests a certification rate of several thousand per year and many hundreds per month. It seems evident that like Energy Star, LEED certification has expanded greatly between 2000 and 2016. This evidence suggests that the incremental gains from green certification exceed the incremental costs. However, there is only scattered information available regarding these costs.

A report to the U.S. General Services Administration [20] examined the incremental costs of LEED Certified, Silver, and Gold ratings for office buildings. It provided ranges for all three categories: 1.4–2.1 percent higher for Certified, 3.1–4.1 percent for Silver, and 7.8–8.2 percent for Gold.

Other work tends toward the lower end of these numbers. Kats [9] reported that the average green cost premium for LEED applied to offices and schools was 2.11 percent for Silver-level buildings, 1.89 percent for Gold, and 6.5 percent for Platinum. Because there was only one building in the LEED Platinum category in Kats' sample while there were 18 Silver and 6 Gold, he estimated the green cost premium at around 2 percent.

Kats [10] (2010) also provided a summary chart showing the incremental costs of 146 green buildings (source not given). The chart shows a median incremental cost of less than 2 percent, although for a few cases the incremental cost was as much as 15–20 percent. These data suggest that while the gains exceed the incremental costs in many instances, in some they probably do not.

Similar estimates have been made by others. Hanford [8] estimated that the incremental cost of achieving LEED Gold at the Providence Newberg Medical Center in Newberg, Oregon, was 1.4 percent of the total construction cost. According to her, a building owner should plan on an incremental cost of 2.0–2.5 percent to cover needed materials plus the green building certification process but can work to whittle it down during the design phase.

4 The discrepancy has been rationalized as due to renters focusing on shorter time periods than buyers, investors discounting revenues from green buildings at lower rates due to lower risks, and expectations of rising energy and water prices, which would result in larger long-term than short-term savings.

5 Renters and buyers tend to know less about building characteristics than owners and sellers; hence, the former may not be willing to fully compensate the latter for their investments in enhanced efficiency. Green certification labels help to resolve such information differences, incentivizing owners to make efficiency investments.

6 Externalities are associated with the combustion of fossil fuels to supply building energy. Green certification does not directly correct for externalities, but some in the literature assert that such certification can result in increased customer recognition and loyalty [13]. This may induce owners to invest in certification beyond what is immediately profitable in terms of rents or sales prices.

7 [24]. LEED also certifies homes, schools, and other types of buildings.

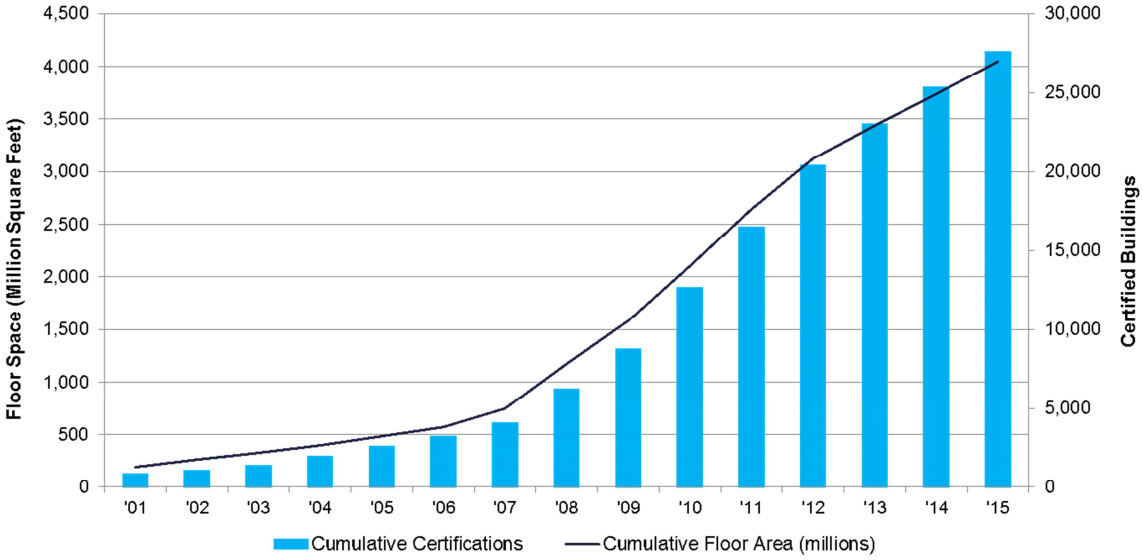

Figure 1. *Cumulative Number of Energy Star Buildings and Floor Space, 2001–2015.*

Table 1. *Estimates of the Added Costs of Investing in a High-Performance Building.*

Source	Year	Estimate
Steven Winter Associates (office buildings) (study for the U.S. General Services Administration)	1994	1.4%–2.1% for LEED Certified 3.1%–4.1% for LEED Silver 7.8%–8.2% for LEED Gold
Kats (1)	2003	2.11% for LEED Silver 1.89% for LEED Gold 6.5% for LEED Platinum (1 building)
Kats (2)	2011	Median cost increment is less than 2%
Hanford	2008	2.0%–2.5% or less
Knox (citing Davis Langdon)	2015	No difference

Knox [11] provided an even lower cost estimate. She cited a study by the firm Davis Langdon that found no significant difference between the average cost of a LEED-certified building and other new construction of the same type. These estimates, summarized in Table 1, show relatively low incremental costs of investing in green characteristics, below estimates of increased rental income or sales prices reported in the literature.[8]

3. Estimated Incremental Costs of ASHRAE 189.1 at Four USAF Buildings

The four buildings examined and their existing green building status are as follows:

1. Tyndall Fitness Center, Tyndall Air Force Base (AFB), Florida (LEED Platinum)
2. C-17 Hangar, Travis AFB, California (LEED Silver)
3. Air Force Weather Agency Headquarters (HQ), Offutt AFB, Nebraska (LEED Gold)
4. Dormitory, Minot AFB, North Dakota (LEED Silver)

The incremental cost estimation process involved three steps. First, the requirements of ASHRAE 189.1 were compared with each of the standards already met by the buildings under study. Of the sample of four, two had achieved LEED Silver, one LEED Gold, and the other LEED Platinum. In each case, facility specifications, design drawings, and LEED submission documents were compared with ASHRAE 189.1 requirements to isolate whether a facility had met or exceeded these requirements. This process identified a series of incremental requirements for each facility whose achievement would entail additional expenditures.

Cost estimates were then developed for these incremental requirements. The principal data sources for interior improvements were RSMeans facility, interior, and mechanical construction data, while pavement and landscaping costs were obtained from RSMeans and U.S. Army Corps of Engineers unit cost factors. Renewable energy cost factors were taken from Solar Power Authority data and Solar Panels Plus, and metering equipment cost data were taken from Submeter Solutions, Inc.[9] All data used for

8 For example, Papineau [16] reports a mean rental increment from green building investment of about 4 percent and a sales price increment of about 9 percent. If median incremental costs are no higher than 2 percent, then in most instances it will pay to make such investments.

9 These data sources are updated periodically, usually on an annual basis. Some data were obtained through interview, but RSMeans data in particular are proprietary and must be purchased through an index of building construction cost data that can be obtained at https://www.rsmeansonline.com/references/unit/refpdf/hci.pdf.

the estimations were as of 2011. Construction, paving, and landscaping costs have not changed much relative to total building costs over the past few years, but installed solar paneling costs have fallen considerably. For that reason, updated estimates of the incremental costs of achieving the ASHRAE 189.1 standard for the four buildings are provided below that take account of this reduction.

The incremental cost estimates were then added together at each facility. In some cases the increments were minimal, below $5,000, but others proved quite substantial. The most important were the requirement to incorporate renewable energy production into the buildings, and in the case of the Air Force Weather Agency HQ, to overlay a parking lot with concrete to mitigate a heat island effect. The total incremental cost was then compared with the construction cost of the facility to estimate the percentage incremental cost imposed by meeting ASHRAE standard 189.1.

4. Illustration and Results

The main incremental costs at the Air Force Weather Agency HQ are shown in Table 2. As noted above, this building had already met LEED Gold requirements.

Table 2. *Summary of Additional Costs at the Air Force Weather Agency HQ Facility Imposed by ASHRAE Standard 189.1.*

Requirement Summary	Estimated Additional Cost
At least 50 percent of site hardscape (roads, sidewalks, courtyards and parking lots of the building project) must be shaded or have high reflectivity	$544,000
Consumption data recording with remote communication capabilities for electricity, gas, and district heat for main systems and some subsystems	$9,000
Extensive metering and submetering requirements and remote reading capabilities to cover potable and reclaimed water	$116,000
Onsite renewable energy systems with production of not less than 6.0 kBtu/sq. ft.	$1,077,000
Exhaust air energy recovery systems with at least 60 percent energy recovery effectiveness	$55,000
Bio-based products must make up at least 5 percent of the cost of building materials	$60,000
Aggregate “minimal cost” requirements	$55,000
Total additional cost	$1,916,000
Increase over base cost of $27 million	7.1%
Increase over base cost without renewable energy requirement	3.1%
Increase over base cost without renewable energy and parking lot repaving requirement	1.1%

In Table 3 incremental costs for all four buildings are reported, with and without the renewable energy requirement.

Table 3. *Incremental Costs of Meeting the ASHRAE 189.1 Standard.*

Building	Initial Cost	Added Cost of Standard	Added Cost Without Renewable Energy Requirement	LEED Status
Air Force Weather Agency HQ	$27.0 million	7.1%	3.1%	Gold
Tyndall Fitness Center	$18.0 million	1.3%	0.3%	Platinum
C-17 Hangar, Travis AFB	$25.4 million	2.8%	1.1%	Silver
Dormitory, Minot AFB	$22.9 million	2.3%	0.4%	Silver

5. Re-estimate with Current Costs of Solar Installation

Data for this study were current as of 2011. Since then, the cost of installing solar panels has decreased substantially. Fares [5] provides a chart indicating that such costs have dropped by around 50 percent over the past five years. This is a national average and might not apply in the particular localities where the four USAF facilities are located. Nevertheless, it gives a reasonable ballpark calculation of what the above cost estimates would have looked like had today’s solar installation costs been used. Applying the 50 percent reduction factor to the renewable requirement, a different picture emerges, as shown in Table 4.

Table 4. *Incremental Costs of Meeting the ASHRAE 189.1 Standard with Reduced Costs of Solar Panels.*

Building	Added Cost of Standard with Original Solar Panel Cost	Added Cost With Reduced Solar Panel Cost
Air Force Weather Agency HQ	7.1%	5.1%
Tyndall Fitness Center	1.3%	0.8%
C-17 Hangar, Travis AFB	2.8%	1.9%
Dormitory, Minot AFB	2.3%	1.4%

6. Discussion

Additional costs of meeting the ASHRAE 189.1 standard relative to one or another LEED standard for the four buildings are estimated at between 1.3 and 7.1 percent. The requirement to obtain high reflectivity at the Air Force Weather Agency HQ parking lot is unusual and unlikely to be widely encountered elsewhere. Without that, the incremental cost at this facility would have been 5.1 percent, resulting in a cost range for the four buildings of 1.3–5.1 percent.

The renewable energy requirement is an important

component of the incremental costs at all four buildings. Without it, the cost range would have been 0.3–3.1 percent. And if the unusual paving requirement were ignored, that range falls to 0.3–1.1 percent.

On the other hand, the renewable energy requirement is an integral part of ASHRAE 189.1. Including it but adjusting the cost estimates to take account of more recent solar installation cost data, the range of cost increments is reduced to 0.8–5.1 percent. That range is further reduced to 0.8–3.1 percent if the paving reflectivity requirement at the Air Force Weather Agency HQ is ignored. This range seems roughly indicative of the incremental costs of meeting the ASHRAE 189.1 standard relative to LEED, in the absence of an unusual factor like the paving requirement.

Because the number of buildings is small, comparisons among them reveal little. The smallest incremental cost pertains to a LEED Platinum building, as would be expected. But the largest pertains to a LEED Gold building, which would not. This is probably due to its large roof size, which would necessitate an extensive solar installation. Percentage incremental costs for the two LEED Silver buildings fall in between.

The four buildings studied were already energy and water efficient. Were the investments calculated from a lower base (say, compared with a standard building), the cost increments would have been larger. Further, these data focus only on costs. Benefit estimates would vary by area, and a renewable energy requirement is likely to pay off more readily in areas with substantial amounts of sunlight or wind.

Overall, the data tend to indicate that additional green requirements such as those included in ASHRAE 189.1 other than onsite renewable energy production do not impose substantial incremental costs once a building has achieved LEED status. Under normal circumstances, the range of cost increments without renewables appears to be around 0.3–1.1 percent. Even with a requirement to produce onsite renewable energy, the incremental cost range is only 0.8–3.1 percent. Although these numbers do not indicate that green investments beyond LEED will pay off, the fact that they are relatively small gives reason to believe that in at least some cases they will.

7. Conclusions

The literature on high-performance buildings contains considerable evidence that markets value such buildings over standard versions. Evidence on the additional costs of these buildings is harder to find. This paper examines the incremental costs of a particular green standard, ASHRAE 189.1, relative to LEED status for a small sample of USAF buildings. The results are presented with and without the costs of providing onsite renewable energy. Without that requirement, the incremental costs are small, on the order of 0.3–1.1 percent, with one exception—when a paving overlay of a parking lot would be necessitated. Using updated data on the costs of installing solar panels, the incremental costs with an onsite renewable energy requirement range between 0.8 and 3.1 percent. The numbers offer promise that stricter building efficiency standards could prove commercially viable in some, if not many, instances, although it seems less likely that a renewable energy requirement would pay for itself in areas with limited sunshine or wind.

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