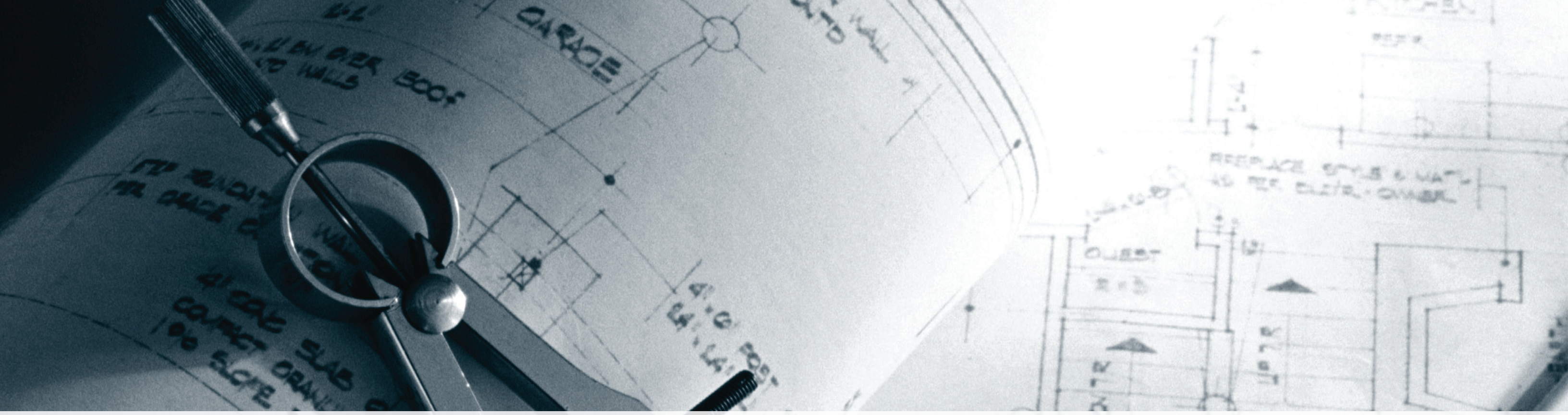

Navigating Sustainability

The opportunities and pitfalls of designing and constructing green buildings

by Gretchen Heberling

2013 Milton F. Lunch Graduate Research Fellow

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Abstract

Many misconceptions about the construction costs, energy performance, and innovative technologies of green buildings persist currently, despite scientific studies demonstrating that sustainable buildings can be constructed at market value, on time, usually perform better than traditional buildings, and have higher levels of occupant comfort. Studies within the past decade, along with their supporting data, are presented to convey the efficacy of sustainable design. Trends in green building and the construction industry as a whole are analyzed. Green building rating systems, standards, and codes are explained and several are investigated in greater detail. Though sustainable buildings are generally healthier and safer, several aspects of their design and construction contribute to unique additional risks. These risks, best practices for design professionals in order to mitigate them, and relevant contract documents are presented. A list of resources for project teams working on green construction projects is also provided.

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Introduction

Though the concept of sustainable design is not novel, the meteoric rise of green building at the turn of the 21st century left many in the building industry dubious of its merits and concerned that sustainability was just a trend and would have no lasting impact on design processes, project delivery, and construction methods. Industry professionals from architects to developers raised questions regarding green buildings' cost effectiveness, energy efficiency capabilities, and return on investment.

Sustainable buildings are increasingly becoming the norm, and most of the qualms about their financial viability have been put to rest as more and more AEC[1] firms complete green projects at budget and on time. As the market share of sustainable buildings continues to increase, meaningful data on their performance has begun to be analyzed. With more case studies to compare and contrast, the knowledge base of sustainable design is being refined and disseminated at a rapid pace.

Navigating the dynamic world of sustainable design and construction can be daunting. Design professionals in the field are now expected to bear more responsibilities, from reaching dictated levels of energy efficiency to achieving green certification for projects. New questions are being raised about liability and risk and how they affect green projects differently. This paper serves to answer some of those questions, report on the progress of the green building industry, and assist the players involved to successfully bring sustainable projects into reality.

Defining Sustainability

A major issue during the infancy of the green movement was the lack of clarity in the definition of terms. Across the world, different buzzwords abounded, from "green" to "high performance" to "sustainable." Different governmental and professional organizations attempted to define them, and their descriptions ran the gamut, complicating things further. One problem that continues to persist is that sustainability is less a prescriptive level of "greenness" that a project should attain and more of a spectrum of possible outcomes.[2]

The American Institute of Architect's document D503-2013 uses the term "sustainable" to "describe, in general, projects that incorporate design and construction practices that are intended to offer benefits to the environment, enhance the health and well-being of building occupants, or increase energy efficiency."[3] This clear and concise definition helps to show that sustainability can be achieved in a variety of ways and is a combination of intent, application of design philosophy and practices, and results comprised of quantitative and qualitative benefits.[4]

The Energy Independence and Security Act of 2007 (EISA) defines several attributes of "high-performance" buildings: reduced energy, water, material, and fossil fuel use, improved environmental quality (IEQ) for occupants, improved worker productivity, and lower life-cycle costs when compared to baselines for building performance.[5] "'Green' is a more inclusive term used to indicate buildings that are designed to be highly energy efficient, to meet green building certification systems, or to be otherwise regarded as sustainable."[6]

Many professionals use these three terms interchangeably, without much thought spent on which specific sustainable practices they are referring to. This muddling of terms and definitions will probably not be resolved in the near future, so design professionals should be careful to ensure that clients and project team members alike comprehend the intended meaning behind these buzzwords.

Costs and Benefits of “Going Green”

In the early 2000s, many members of the AEC industry were dubious about green buildings due to the perceived upfront costs. These sentiments have persisted, even in the face of mounting studies demonstrating that the additional costs of producing a green project is minimal, if anything at all.

These concerns also fail to acknowledge that, even if there is a small premium charged at the front end, many sustainable buildings offer savings in the long run through lower operating costs, higher rents and sales prices, and financial incentives provided by the government. Depending on the design and construction strategies used, a green building can provide myriad benefits: lower energy and water usage, reduced CO_2 emissions, increased occupant productivity and health, increased occupancy and rental rates, higher property value, and enhanced branding opportunities.

Misconceptions about sustainability are pervasive, and many critics of green buildings offer opinions, but little data to support their claims. For example, in a 2010 article, Dawn Killough, a blogger for *Green Building Elements*, wrote a post that did little to help the industry understand how projects work. Instead, she made sensational statements about theoretical design issues that prevent energy efficiency goals from being met, providing no case studies or actual data.

Instead of acknowledging that communication issues and unintentional design promises are usually the root of the problem, she uses large trees blocking PV panels and million-dollar water treatment systems as the only design issues that come to mind.

> *...the cost to build all these great systems is all too often prohibitive. Unless the owner is a ‘greenie’ themselves or has a very strong green agenda, this initial cost increase often scares them off.*
>
> *Or there may be problems implementing the green plans in the ‘real world’. The weight of the green garden roof and the solar panels may simply be too much for the structure to bear...It would be wonderful if problems like this were caught during design, but we all know that just doesn’t happen.*[7]

No cost data accompanies this article, nor does she suggest any ways to improve the effectiveness of the design process (some of which include organizing intensive green design workshops, also called “charrettes,” in order to effectively educate the owner, utilizing integrated project delivery methods and building modeling to resolve design issues before they arise, and conducting life cycle analysis to calculate realistic cost estimates). She neglects to provide her readers with information on any of the systems she mentions, instead writing her personal opinion and unsupported anecdotes: “[Underfloor air distribution] systems, however, are more expensive than standard above-ceiling ductwork…and don’t allow temperature control,[8] just air volume and direction controls. Sweaters may be needed on a 90 degree day!”

By allowing misinformation like this to proliferate, the building industry is doing itself a disservice. This section will serve to reevaluate the relevance of old concerns and address common false rumors in the realm of sustainable design and construction.

Do Sustainable Buildings Cost More than Conventional Buildings?

The short answer to this question is: no. But, it all depends.[9] In 2004, and again in 2006, Davis Langdon investigated the real “cost of green,” and his results[10] showed that “there is no significant difference in average costs for green buildings as compared to non-green buildings.”[11] Though green buildings cost less on *average*, not every green building costs less than every conventional building. Langdon commented on the difficulty in comparing green buildings to conventional ones on a case-by-case basis:

1. There is large variation in costs of buildings, even in the same building category.
2. There are low-cost and high-cost green buildings.
3. There are low-cost and high-cost conventional buildings.

Given these discrepancies between even *similar* buildings and the many sources of variation between projects, the wisest answer to this question is one taken from a broad sample of the panoply of studies conducted over the past decade.

It can be seen that despite a tumultuous recession and increases in construction costs across the board, sustainable projects are rarely prohibitively expensive. In 2003, Gregory Kats, in cooperation with the Sustainable Building Task Force of California, found that green buildings cost roughly 2% more to build than conventional buildings. Langdon's studies in 2004 and 2007 concurred with Kats'.

A very comprehensive study released in 2013 by the National Academy of Sciences evaluated 25 studies from 2006 onward that conducted analysis of at least 6 buildings.[12] This study concluded that "design and construction cost (variously defined) would range from zero to 8 percent higher for green versus conventional buildings, depending on the method used to calculate the costs and the type of building."[13]

Though a developer or owner on a building project may be averse to a potential 8% premium for sustainable design practices, they should be cognizant that first costs make up a small portion of a building's life-cycle costs:

> *"The additional incremental costs to design and construct high-performance or green buildings are relatively small when compared to total life-cycle costs...During the life cycle of a building, design and construction costs typically range from 5 to 10 percent of total costs, while operations and maintenance costs account for 60 to 80 percent of total costs. Thus, the additional incremental costs to design and construct high-performance or green buildings are relatively small."*[14]

This would provide little comfort to a developer or owner in the current market, as many of them are not the end-users of their buildings and often do not see the financial benefits of lower operating costs. Methods of spreading the financial benefits to the design and construction team, owner, and occupants are being investigated. Green leases encourage tenants to reduce their energy use by using sub-metering to monitor each tenant individually, rather than as an entire building of residents. Cliff Majersik of the Institute for Market Transformation says "there is currently a split incentives problem. The ultimate beneficiary [of the high performance building] is the occupants, so some of that benefit needs to be funneled to the landlord, the builder, and others, so that everyone comes out ahead."

During the life cycle of a building... operations and maintenance costs account for 60 to 80 percent of total costs.

Are Green Technologies, Materials, and Systems Complicated and Expensive?

Many green strategies cost nothing; design considerations for a building's site, shape, mass, and orientation in accordance with passive solar design and optimal window placement for daylighting can result in energy savings and increased occupant comfort. Rules of thumb for passive solar design include orienting the building's longest dimension along the east-west axis, incorporating thermal mass to store heat, and offering glazing and shading control.

According to McGraw Hill's 2013 *SmartMarket Report: World Green Building Trends*,[16] 89% of firms surveyed have installed or specified some type of green product. Over 60% of firms used sustainable electrical, mechanical, and thermal systems, with over half using green building automation systems and waste management practices. Half of the firms surveyed specified or installed sustainable finishes and flooring, and a third of them used green furnishings.

Use of recycled materials is also a cost-effective way to achieve a more sustainable building project. Architect Carl Elefante said that "the greenest building is the one already built;" incorporating used building materials into a project is a sustainable practice that diverts more waste from entering landfills and reduces the carbon footprint of a project, as well as its embodied energy.[17] Building elements such as masonry and structural steel are commonly recycled, and inclusion of these used materials is often a method to achieve green certification. The liability issues with incorporating used building materials into a project are addressed later in this paper, in the "**Risks Unique to Sustainable Buildings**" section.

Materials that are certified by a trustworthy organization are generally comparable in price to conventional products. GREENGUARD, which certifies interior products and materials that have low chemical emissions, states that "typically there is not a cost premium associated with selecting certified products. Most manufacturers improve on their standard products to ensure their indoor air quality performance."

There are several forms of product certification: first-person, second-party, and third-party claims. First-person claims are made by the company that produced the product. Usually, a company will provide a Material Safety Data Sheet (MSDS), which may not have been verified by an independent party. These are not necessarily backed by strong scientific data and are the least trustworthy form of product certification. With second-party certifications, the certification is provided by an organization or association to which the manufacturer belongs. Second-party claims, made by an entity other than the manufacturer, such as the Carpet & Rug Institute's (CRI) Green Label program, can be legitimate, but they need to provide data and results to prove that they have conducted testing. Third-party certifications are provided by truly independent groups. Therefore, third-party claims are the most credible. To be third-party certified, the manufacturer typically pays an independent group to test and verify the product. Examples of this type of certification include GREENGUARD or Green Seal.[18]

Green technologies are offered at a variety of price points, just like conventional building technologies. Though renewable energy sources like solar, wind, biomass, and geothermal are free, the equipment required to collect and store the energy is generally more costly than relying on the fossil fuel-dependent grid. A way to compare costs for different energy sources is to consult the levelized cost, which is a "summary measure of the overall competitiveness of different generating technologies, [representing] the per-kilowatt hour cost."[19]

Not all green materials, construction methods, systems, and processes are inexpensive, or comparable to the cost of conventional building practices, when judging them solely on face value. Technologies like high-performing HVAC equipment and glazing systems, green roofs, low-flow plumbing fixtures, and smart lighting systems may have higher first costs than traditional building methods, but in order to realize the full value of a design choice, design professionals should conduct a life-cycle assessment of potential options. Many owners are primarily concerned with first cost, but if properly educated on the subject of sustainability, they may be encouraged to consider the life-cycle costs of building green:

> *It is remarkable that after ten years of data showing the cost premium for green buildings averages between zero to 2%, that so many decision makers still see the costs of construction to be an obstacle. It may be that the obstacle is the high cost of construction in general, whether the project is a*

> *green building or not.* ***That these misperceptions persist emphasizes the continuing need for education and information about the true costs and benefits of green buildings.***[20] *[emphasis added)*

A tool to assess the life-cycle of a design element is its "payback period," deduced by conducting an economic analysis of its internal rate of return, net present value, or return on investment. To evaluate this, a design professional could provide the owner with a conventional and green option and calculate the first costs, related energy usage data, operations and maintenance requirements, and the amount of time that it would take to break even on the (possible) additional cost of incorporating the green building element. Extensive research has been conducted on strategies like compact fluorescent light bulbs, double- and triple-pane windows, and increased insulation values in wall construction.[21] On average, the firms across the globe surveyed by the 2013 McGraw Hill *SmartMarket Report* reported a median payback period of 8 years for the additional costs of a new green building.

Due to the ever-increasing variety of options available for sustainable projects, evaluating whether a specific design choice is "worth it" is dependent on the unique aspects of a project, and can't be answered in one sweeping statement. Some materials are more cost-effective in different climates, and some pieces of mechanical equipment are more appropriate for certain building types. In 2007, The American Institute of Architects (AIA) composed a document to offer 50 strategies to achieve a 50% reduction in energy usage; these options would be a good starting point for a design team discussion. Some questions to ask when considering a green strategy are:

1. Is this strategy appropriate for the building's location, site, climate, and occupants?
2. Does it require additional expertise to install properly?
3. What are the qualitative and quantitative benefits?
4. How long is the payback period?
5. Will the incorporation of this strategy help the project achieve green certification?
6. What are the operations and maintenance requirements?

After considering the feasibility of a strategy, ensure that the entire process is extensively documented and the design team, owner, and end-users are substantially educated regarding the installation, operation, and maintenance of the design element. See the "**Risks Unique to Sustainable Buildings**" section of this paper to learn more about the ways to manage the challenges of incorporating innovative products and materials into a project.

Do Green Buildings Actually Perform Better?

> *The research on high-performance or green buildings inherently incorporates some level of subjectivity because of the unique nature of buildings, diversity in baselines for comparison studies, and the lack of a standard protocol for research on this topic. All buildings differ in terms of location, materials, design, size, function, technologies, operational practices, and other factors, which influence overall building performance. The diversity in building design and the multitude of factors that contribute to any building's performance make it difficult to isolate the specific factors that contribute to energy use, water use, or other performance measures.*[22]

As with construction costs and building strategies, it remains difficult to make generalized statements about sustainable buildings in the aggregate, as the quote above states: each building project is unique. The increased use of building energy modeling also complicates the issue by creating two types of performance: the modeled building's designed performance and the actual building's post-occupancy performance. Five studies conducted over the past 5 years all conclude that green buildings perform better than conventional buildings.

The New Building Institute's 2008 study of LEED for New Construction buildings concluded that LEED certified buildings use 25-30% less energy than the national average, with Gold and Platinum buildings having 45% lower energy use intensity (EUI) values than non-LEED buildings. (For a detailed explanation of LEED and other rating systems, please refer to the "**Rating Systems: Benefits and Drawbacks**" section.

The 2011 *Greenprint Performance Report*, which includes 2,703 property submissions representing 700 million square feet across 46 countries, found a median office EUI of 67.2 kBtu/ft^2, compared to the 2003 CBECS[23] average of 193 kBtu/ft^2.

The General Services Administration's 2011 study of 22 sustainably designed public buildings concluded that they use 25% less energy, reduce operational costs by 19% and CO_2 emissions by 36%, and have 27% higher occupant satisfaction than typical GSA buildings.[24]

Five studies conducted over the past 5 years all conclude that green buildings perform better than conventional buildings.

In their 2012 study, *Do Green Buildings Outperform Conventional Buildings? Indoor Environment and Energy Performance in North American Offices*, Guy Newsham et al. analyzed a year of data from 100 LEED-certified buildings twinned with similar conventional buildings (utilizing CBECS data), and established that, on average, LEED buildings used 18-39% less energy per-floor area than their conventional counterparts.[25] However, 28-35% of LEED buildings used more energy than their twin buildings, suggesting that if sustainable measures are not planned, installed, and managed properly, a green building can in fact perform worse than a traditional building.

In the National Academy of Science's 2013 study, they state, "The 13 studies that measured actual energy used (not modeled energy) found that high-performance or green buildings, on average, used 5 to 30 percent less site energy than conventional buildings."[26] They went on to note that green buildings have water use reductions of 8 to 11 percent.

Innovations like building energy modeling are making it easier to make predictions about a project's energy loads, but present problems when they are relied on too heavily. Measured EUIs for over half of the projects analyzed by the New Buildings Institute study deviated by more than 25% from design projections, with 30% of the buildings performing better than their models, and 25% performing worse. Models generally underestimate energy and water usage; "this is because (1) such models assume perfection in manufacturing, installation, and operation of buildings and their systems; and (2) such models do not include certain heat losses, because they are too difficult to calculate."[27] Modeling presents new risks for the design professional, and these risks and ways to mitigate them are addressed in the "**Risks Unique to Sustainable Buildings**" section of this paper.

Is There Demand for Sustainable Buildings?

Yes, there is demand for green buildings, and it is ever increasing. Client demand is the primary trigger driving firms' future green building activity in the U.S., according to McGraw Hill's 2013 *SmartMarket Report*,[28] with market demand as the tertiary trigger, following behind corporate commitments. Building green is becoming less of a pursuit rooted in "doing the right thing," and is, rather, largely a business opportunity. 63% of planned new commercial construction is sustainable, a jump from 48% in 2008, with no signs of decline.

Several demographics are demanding sustainable buildings, but may not always want to pay a premium for the privilege. Large companies (who are progressively creating more internal commitments to leasing green office spaces exclusively) and other blue chip tenants may not even consider tenancy in a conventional, uncertified building. These commercial tenants are critical to increasing the value of the building; to ensure a higher caliber of tenant, a building owner should view green strategies as necessary measures for all new construction.[29] According to the Institute for Building Efficiency's 2013 *Energy Efficiency Indicator Survey*,[30] 30% of commercial, industrial, and institutional organizations are willing to pay a premium for tenant space in certified green buildings.

A new generation of renters—millennials—present a large financial opportunity for building owners. "Kelly Vickers, national director of sustainability for Phoenix-based Alliance Residential Co…says 'Millenials, a key cohort of the rental market, see value in green apartments and sustainability-focused companies, and green certified buildings can help attract this key demographic.'"[31]

Do Green Buildings Actually Command Higher Rents?

The following cited studies demonstrate that green buildings have higher occupancy rates and rent and sell at higher rates than conventional buildings *if they are third-party certified*. Substantive studies on rental and sale rates for uncertified, but sustainable, properties have not been conducted. This makes sense, as the definition of "sustainable" is variable, and would add inconsistencies when comparing green buildings to conventional properties.

In the 2009 update to their study, *Do Green Buildings Make Dollars and Sense*, Pogue and Miller found that aggregated data on LEED-certified buildings over three years showed an average 3.1% improvement in both rental rates and building occupancy in comparison to the general market.[32]

Eichholtz's 2009 study, *Doing Well by Doing Good?*, sampled CoStar data from about 10,000 office buildings.[33] The data were divided into around 900 clusters, each containing one green-labeled building and nearby unlabeled buildings. The study found that LEED-certified buildings commanded 5.2% higher rents, with Energy Star labeling offering a 3.3% increase in rents, controlling for the quality and location of the buildings. Selling prices of green buildings were also 11% higher for LEED-certified and 19% higher for Energy Star-labeled buildings. Eichholtz also reexamined some 2007 data and reported 6% higher effective rents for certified buildings in general, which reflects the higher occupancy rates, on average, of green buildings.

A 2010 study conducted by Jonathan Wiley, et al., observed leasing activity in 46 markets across the U.S. and concluded that certified buildings achieve significantly higher rents, 7.3-8.6% for Energy Star-labeled properties and 15.2-17.3% for LEED-certified properties.[34] Occupancy rates are also higher by 10-11% for Energy Star-labeled properties and 16-18% for LEED-certified properties. Both Energy Star-labeled and LEED-certified buildings also sell at significant premiums over comparable properties, 8% and 18%, respectively.

Fuerst's 2011 study, *Measuring the Effects of Environmental Certification on Office Values*, sampled 197 LEED and 834 Energy Star buildings, as well as over 15,000 benchmark buildings.[35] The report found that LEED-certified properties had a rental premium of 5%, with 4% for Energy Star properties. Sales prices were 25% higher for LEED and 26% higher for Energy Star.

Furthermore, there is an apparent rent discount being applied to conventional buildings. In Kaplow's 2012 report, *Green Buildings Demonstrate Significantly Higher Office Rental Rates*,[36] his firm's clients and friends of the law firm demonstrated that from 141 lease transactions, there was a 7.2% rental rate premium for LEED offices, while there was a 4.1% rental discount on non-certified offices. It should be acknowledged that this study did not conduct a statistically pure analysis, and is more of an anecdotal look at rental rates in the U.S.

This does not mean that the real estate valuation industry is acknowledging the inherent value of green buildings. In Warren-Myers' 2012 report, *Value of Sustainability in Real Estate*, she states:

> *As aforementioned, many stakeholders are awaiting financial justification which they are expecting from the [real estate] valuation profession. However, limited acknowledgement of any relationship between sustainability and market value by valuers means limited investment. It is the same circle of blame, where valuers require evidence to report the change, but change will not occur if valuers do not present a positive relationship between sustainability and market value. Therefore, research investigating the perceptions and actions of investors and occupiers are required.*[37]

She maintains that existing studies are not sufficient; "from a statistical and real estate practice perspective, they lack the reliability in the data and assessment methods to be used as evidence for valuation practice."[38]

Fortunately, organizations are working to improve the real estate industry's perception of green building. Cliff Majersik of the Institute for Market Transformation (IMT) said that his organization is working on standards for appraising buildings that incorporate sustainability into the value of buildings. IMT is also creating a guidebook and offering continuing education programs for appraisers to better their understanding of what green buildings are worth.

Do Green Projects Require Dedicated "Green" Staff?

In the last decade, as sustainable design and construction expertise has emerged from a niche specialty into an expected knowledge base, this question is becoming increasingly irrelevant. McGraw Hill's 2012 report, *Construction Industry Workforce Shortages: Role of Certification, Training and Green Jobs in Filling the Gaps*[39], states that green jobs currently comprise 35% of the construction workforce and that is projected to increase to 45% by 2014. 66% of respondents believed that green construction will be the norm for their firm (and 70% for their profession/trade) by 2016.

As green becomes mainstream, more and more firms are finding that their accredited employees afford them advantages. 71% of firms surveyed found that having employees with green certifications or accreditations increases the competitiveness of their firm and its ability to win contracts.

To achieve third-party green building certification, having a dedicated sustainability consultant on the project is highly advisable, but that does not necessarily mean that that staff member must be in addition to a firm's existing employees. Increasingly, architects and engineers are pursuing accreditation in order to become knowledgeable enough about sustainability in order to make the hiring of additional consultants unnecessary.

This is not to say that sustainability consultants are not useful, but that these professionals are becoming more integrated into the design process as design team members who wear multiple hats. In the coming years, it is possible that there will be less need for the modifier "green;" "green architects" and "green engineers" may soon go back to being architects and engineers as the sustainability expertise will be assumed and expected.

Sustainability Trends

This section presents and analyzes data from three recent reports: Turner Construction Company's

Green Building Market Barometer (2012),[40] McGraw Hill's *SmartMarket Report: World Green Building Trends* (2013),[41] and the Institute for Building Efficiency's *Energy Efficiency Indicator Survey* (2013).[42] Turner and McGraw Hill's respondents are mainly AEC firms with a few owners and developers, while the Institute for Building Efficiency's respondents are largely owners, facility managers, and VPs who review and monitor facility energy usage.

By consulting these reports on the state of sustainability in the construction industry, it can be seen that sustainability is becoming increasingly important to AEC firms, owners, and developers alike.

Level of Commitment to Sustainable Practices

Turner: 56% of surveyed executives said that their companies were extremely or very committed (34% somewhat committed) to following environmentally sustainable practices in their operations. 81% of those surveyed said that their companies were extremely or very likely to invest in energy efficiency improvements.

McGraw Hill: 40% of U.S. firms reported that more than 60% of their work in 2012 was on green projects. This is projected to increase to 53% by 2015. 22% reported that 31-60% of their work in 2012 was on green projects, with a projected increase to 30% by 2015. Only 2% reported no green involvement in 2012, with a projected decrease to 0% by 2015.

Institute for Building Efficiency: 64% of organizations reported having carbon reduction goals, and 73% had energy use reduction goals. Having public goals leads to higher use of strategies and actions to improve efficiency. 73% of organizations intend to achieve nearly zero, net zero, or positive energy status for at least one new facility. 59% of executives invested in energy efficiency projects in 2013, down from 63% in 2012. Available capital is the main challenge for 31% of respondents, followed by financial criteria (20%) and certainty of savings (17%).

Analysis: Across the board, AEC firms, owners, developers, and organizations are increasing their level of commitment to sustainability, whether that is by designing more green projects, investing in more energy efficiency improvements to current buildings, or planning new high-performance buildings. The small downturn in investment in energy efficiency projects is mostly due to external pressures, and with the recent post-recession upturn, those numbers should increase.

Across the board, AEC firms, owners, developers, and organizations are increasing their level of commitment to sustainability.

Economic, Social, and Environmental Reasoning for Going Green

Turner: 68% of respondents report committing to green practices because it is "the right thing to do," 67% because of their impact on the company's brand and reputation, and 66% because of the cost savings. Most (84%) pursue green construction for the reduced energy and operations and maintenance costs.

McGraw Hill: In the U.S., the top triggers driving future green building activity are client demand (41%), internal corporate commitment (32%), market demand (30%), lower operating costs (30%), the sentiment that it is the right thing to do (29%), enhanced branding/public relations (25%), and market transformation (24%). The top social reasons for going green are increased health and productivity benefits (56%) and the encouragement toward sustainable business practices (43%). The most important environmental reasons for building green are: reduced energy consumption (78%); reduced water consumption (32%); improved IAQ (25%); protection of natural resources (19%); and lowered greenhouse gas emissions (14%).

Institute for Building Efficiency: Cost savings remains the most influential factor for U.S. companies' energy efficiency decisions, followed by government and utility incentives, increased asset value, enhanced brand/image, and energy security.

Analysis: The studies disagree on which is the primary trigger driving green activity, but all three concur on several similar reasons for AEC firms and organizations alike: social responsibility to promote environmentalism; enhanced branding; cost savings due to lower energy use and lower operating costs; client/market demand; and governmental financial incentives.

Pursuance of Green Building Certification

Turner: Fewer companies plan to seek LEED certification (48% of those surveyed, down from 61% in 2008). 52% of those who are not likely to seek LEED certification prefer to use their own company's green building standards. Cost (82%), time required for the certification process (75%), staff time dedicated to pursuing certification (79%), and the perceived difficulty of the certification process (74%) are the leading reasons for opting out of certifying. 41% of respondents said that it was somewhat likely that they would consider certifying with a different third-party organization (63% would consider Energy Star, 25% Green Globes, and 21% Living Building Challenge).

McGraw Hill: 91% of U.S. firms report using LEED, and 61% of firms believe that rating systems provide a common industry language. Perceived benefits of using green building rating systems are, globally: they create the ability to create a better performing building (69%); certification provides marketing and competitive advantage/recognition (67%); as well as an opportunity to learn more about the specific elements of a green building (43%); they encourage use of an integrated design team (41%); and they offer governmental or local financial incentives (20%). For those who choose not to certify their building projects, 61% report that it is too costly and time intensive, 24% report that rating systems are not tailored to their regional climate and cultural implications, and 15% report that rating systems are difficult to understand (down from 36% in 2008).

Analysis: The two studies do not agree on the current prevalence of certification (LEED, specifically), but both acknowledge that cost and time required for the certification process is a hindrance to widespread market acceptance. Firms find that certification allows for enhanced marketing opportunities. Industry professionals are open to trying other rating systems, and there has been a large increase in the level of understanding AEC firms have with regards to rating system requirements and documentation processes.

Perceived Benefits of Green Buildings

Turner: 75% of those surveyed cited increased building value, higher occupancy rates, lower total 10-year costs, better indoor air quality (IAQ), increased health and well-being of occupants, and higher rents as benefits of building green.

McGraw Hill: New green buildings provide business benefits of decreased operating costs over one year for 11% of survey respondents and decreased operating costs over 5 years for 28% of respondents. The average payback period reported for new construction is 7 years; 4 years for retrofits. Global respondents listed their top benefits of green building: lower operating costs (76%); higher building value at point of sale (38%); documentation and certification providing quality assurance (38%); future proofing assets (36%); and education of occupants about sustainability (31%), higher rental rates (27%), increased tenant productivity (25%), and higher occupancy rates (25%). "As a firm's green activity level increases, so does the evaluation of operating cost savings."[43] 48% of firms at the highest level of green activity reported operating cost reductions of over 10% over one year.

Analysis: Both studies agree that green buildings offer lower operating costs, higher rental rates, increased building value, and increased productivity and well-being of occupants/tenants.

Challenges to Increasing Green Building Activity in the United States

Turner: 61% of executives felt that the lengthy payback periods, difficulty of quantifying benefits of sustainability (49%), and higher construction costs (62%) are extremely or very significant obstacles to the construction of green buildings.

McGraw Hill: "Whether real or perceived, higher first cost for green building efforts is viewed as the most significant obstacle."[44] U.S. firms are also concerned with being able to justify capital expenditures when paybacks are coming from another budget line item; this is a problem rooted in accounting systems and will continue to be a challenge.

Analysis: In the U.S., a major obstacle to green building is the one-track attitude of owners toward first cost and the persistent belief that green buildings cost significantly more to design and build. A second concern is the quantification of sustainable goals and performance.

Impact of Financial Incentives

McGraw Hill: Around one third of global respondents reported having had no impact from financial incentives; only 49% of U.S. firms take full advantage of them. Many owners are reported to be unaware of financial incentives.

Analysis: It is apparent that there needs to be more widespread education about pursuance of tax incentives and rebates to make sustainable projects more cost effective.

Efficiency and Renewable Energy Measures

McGraw Hill: 89% of firms report installing or specifying some type of green product. 63% of firms installed or specified green electrical products, 60% mechanical, 60% thermal and moisture protection, 57% building automation systems, 52% waste management systems, 50% finishes, 50% flooring, and 34% furnishings.

In a 2012 study of 114 LEED for New Construction buildings, the following technologies were implemented at the following rates: >70% high performance windows; >60% high insulation walls/roofs and occupancy sensing; >50% cool roof solutions (green roof, high solar reflective index), operable windows, and adaptive lighting; >40% compact fluorescent bulbs; >30% direct digital control, variable frequency drives; and >20% wall light redirection (light shelves), roof light redirection (skylight luminaires), individual thermostat controls, variable-air-volume, and high efficiency water heaters.

83% of firms use renewable energy in some way, up from 67% in 2008. Solar power is the most popular form of renewable energy, currently used by 67% of respondents. Geothermal is used by 27%; that is expected to increase to 44% by 2017. Wind is used by 14%; that is expected to increase to 42% by 2017.

Institute for Building Efficiency: The most popular green strategies are lighting and HVAC system improvements.

Analysis: The three studies seem to come to different conclusions with regards to the most popular green strategies. Despite this lack of congruence, it can be seen that a variety of improvements can be made in many different sectors of a building project, with high-performance lighting, HVAC, glazing, and insulation systems leading in popularity. The feasibility and application of each strategy will depend on the specifics of the project. Renewable energy sources are becoming increasingly prevalent, and will continue to be, especially geothermal and wind power.

Evaluation of Green Products

McGraw Hill: One third of respondents use third-party certifications for green products. Respondents evaluate the “greenness” of products in the following ways: energy efficiency (74%); proven industry performance data (54%); nontoxicity (49%); recycled material content (49%); proven lifecycle data (46%); durability (42%); and certified by a third party (36%).

Analysis: In the last decade, concerns about “greenwashing” have diminished and a larger portion of firms are aware of how to deduce whether a product or material is truly sustainable. These numbers should increase as more certifying agencies pop up and more industry professionals are better educated about evaluating green products.

Energy Data Collection and Analysis

McGraw Hill: 52% of firms report using metrics to track lower operating costs. 37% of firms are not using any metric to track performance of green building investments.

Institute for Building Efficiency: 54% of respondents measure and record at least weekly (29% monthly). 45% report analyzing energy data monthly, 32% quarterly, and 19% at least weekly.

Analysis: Both of these studies show two things: 1) A large portion of firms and owners are not measuring performance, and 2) those who do collect and measure performance are analyzing their data at a variety of frequencies.

Green Building Rating Systems, Standards, and Codes

Quantification of sustainability has been a challenge since the inception of the green revolution; since the 1990s, a variety of different green building rating systems and standards have been developed to certify projects have been designed to attain, or perform at, certain levels of sustainability. A more recent advancement has been the creation and adoption of green building codes, whose energy requirements are becoming more stringent with every new edition, in an attempt to reach benchmarks required by the 2030 Challenge.[45]

Initially, these standards and codes began as voluntary options for progressive design teams and building owners; currently, there are many communities that require public buildings to attain certification, and “at least 47 local governments, from Baltimore, Maryland to Lincoln, Nebraska are on the cusp of adopting the International Green Construction Code together with ASHRAE[47] 189.1 as an optional green building code.”[48] Commitments made by the American Recovery and Reinvestment Act of 2009, coupled with the mass adoption of LEED requirements by 14 federal agencies and departments (as of 2011), demonstrate that the U.S. government is serious about making green building the norm, at least for publicly funded construction.[49]

> *In considering potential certification systems..., it may be necessary to distinguish between certification and building performance. A building that has achieved a specific certification will not necessarily realize enhanced performance, and therefore may not meet an owner’s performance expectations. Conversely, a building that meets the owner’s performance expectations or incorporates sustainable design and construction elements may not be eligible for a particular certification because it may not meet all of the certification requirements.*[50]

The decision to attain certification for a building project should be one that is extensively discussed with all members of the design team, the contractor, the owner, and any consultants on staff for the project. Committing to achieving a specific level of certification is problematic, risky, and may introduce an assumed higher standard of care for the design professional and unrealistic expectations on the part of the owner; this issue (and others) are discussed and analyzed in the section entitled "**Risks Unique to Sustainable Buildings**" of this paper.

Rating Systems: Benefits and Drawbacks

There are three main types of green building standards: prescriptive, performance-based, and outcome-based. Each has pros and cons, and depending on the building project, budget, location, and sustainability goals of the building owner, a specific rating system type may be more appropriate or feasible than the others. Each of the three types will be introduced, along with applicable examples of popular rating systems and standards.

Prescriptive

These standards describe or specify minimum or maximum values for various design elements; for example: R-values of insulation, efficiencies of HVAC equipment, etc. These standards are easy to follow because they require little analysis, no time-intensive and costly modeling, and the technical specifications are simple and usually require items that are common products.

Though straightforward, this type of standard does not encourage a whole building approach to achieving energy savings and may lead to missed opportunities for energy efficiency. Also, these standards sometimes overlook passive strategies such as building orientation, daylighting, thermal mass, natural ventilation, and options like integrated appliances and mechanical equipment.[51]

New Building Institute's Advanced Buildings: Core Performance

Applicable for small- to medium-sized buildings, the *Core Performance Guide* provides more than 30 criteria to define the high performance standards for the building envelope, lighting systems, HVAC equipment, power systems, and controls of a building project. The *Guide* is designed to achieve energy reductions of 30%, and is compatible with LEED as an option to achieve Energy and Atmosphere points (though affords fewer points than conducting an energy model would).[52]

Performance-Based

This type of standard contains broad, qualitative energy efficiency goals that require modeling to verify compliance. These goals are usually expressed in terms of a "percent better than" baseline. These standards allow flexibility for design innovation and by requiring modeling, allow for evaluation of various combinations of design strategies, components, and technologies.

Issues arise with modeling, as it can be expensive and require significant staff expertise and time commitments, and models are still predictions, not enforceable, guaranteed outcomes.

The U.S. Green Building Council's Leadership in Energy & Environmental Design (LEED)[53]

Currently, the most widely used (and discussed, both favorably and critically) rating system package, LEED, is a suite of standards, updated every few years, that works on a point system to establish different levels of certification. LEED v4 is comprised of 5 categories: Building Design & Construction, Interior Design & Construction, Existing Buildings: Operations & Maintenance, Neighborhood Development, and Homes. As of May 2013, there are 44,270 registered and certified projects in the U.S., a footprint of over 595 million gross square meters.[54]

LEED for New Construction (LEED-NC) has a total of 110 possible points, which can be achieved through prerequisites and credits. There are 4 possible levels of certification that can be achieved by exceeding the following point thresholds: Certified (40-49 points); Silver (50-59 points); Gold (60-79 points); and Platinum (80+ points). Credits are split into categories and have the following point amounts allotted to them: Location & Transportation (16 points); Sustainable Sites (10); Water Efficiency (11); Energy & Atmosphere (33); Materials & Resources (13); Indoor Environmental Quality (16); Innovation (6); Regional Priority (4); and Integrative Process (1).[55]

The AIA does not explicitly recommend one specific rating system; regardless, in 2008, their Sustainability Discussion Group (SDG) had this to say: LEED's "continued development in life cycle assessment and requirements for renewable energy or carbon reduction targets for certified projects…make this system an effective resource for architects."[56]

The SDG had a few concerns about LEED-NC v2.2,[57] namely that it did not put enough emphasis on reduced water usage and CO_2 emissions and use of sustainably sourced and certified materials and did not require commissioning or generation of life-cycle assessment data. Since 2008, LEED-NC has evolved to address all of these issues in some way. LEED v4 now contains a prerequisite credit for commissioning of the building envelope and development of a commissioning plan for mechanical, electrical, renewable energy, and plumbing systems. LEED v4 also contains credits for use of certified products and materials and use of green power or purchase of carbon offsets, and has increased its emphasis on reduction of water usage.

The cost and time required for the extensive documentation process is another complaint directed at the USGBC:

> *LEED version 3, activated in 2009, brought more bureaucracy, longer delays, additional costs, and even slower response times [than LEED 2.2]. Documentation continues to be laborious and time consuming, customer service has not improved, and LEED Online, the internet portal for LEED project certification, continues to make life for project teams more difficult with each new version. Even more daunting is the latest iteration, LEED version 4, which represents a seismic shift in the structure and requirements for this green building certification system.*[58]

A damning blog post by the *New Republic* commented on the ineffectiveness of LEED ratings; data released by New York City on the Platinum-rated Bank of America (BOA) Tower showed that the building "produces more greenhouse gases and uses more energy per square foot than any comparably sized office building in Manhattan."[59] The post also referenced a *USA Today* examination of 7,100 LEED-certified commercial buildings which found that developers and designers target the easiest and least expensive credits, often sidestepping the more costly green strategies that often have more effect on the indoor environment and energy usage. The design team for the BOA Tower did something similar; they only pursued Core and Shell certification, which neglected the enormous plug loads of the computers that comprise almost one third of the building's space. Many critics are responding to this by lambasting the USGBC and questioning why the USGBC does not make it a practice of theirs to revoke certification when a LEED building does not perform as designed.

The USGBC encourages building projects to establish a timeline of effective sustainable activities by attaining LEED-NC certification when a building is designed, and pursuing LEED for Existing Buildings (LEED-EB) certification once the building is occupied.

> *For example, a building in Potomac Yard in downtown Crystal City that is a LEED-NC certified building also received an Energy Star plaque, followed by a LEED-EB certification, followed by four more Energy Star plaques, followed by another LEED-EB certification…a rating system like LEED is a composite of positive outcomes.*[60]

The USGBC finds that achievement of desired certification levels has much to do with the design team. Very high performance buildings such as zero net energy and LEED Platinum rated buildings usually have the most experienced designers and consultants on staff and are often delivered at market rate. LEED Gold projects often have wide variance in cost, mostly due to the design team's lack of familiarity with the documentation process, while most teams can deliver LEED Silver-rated buildings at market rate.

Energy Star

A governmental program created by the U.S. Environmental Protection Agency, Energy Star is a rating program in which new commercial construction must achieve a score of 75 or higher using their Portfolio Manager and be verified by a licensed professional[61] through a building inspection. The current version of Energy Star, Version 3, requires that a building perform among the top 25% of similar buildings in the U.S.,[62] as well as meet the EPA's performance levels for occupant comfort, lighting, and indoor air quality.

The process for calculating a project's energy performance score is simple. Using Target Finder ("the EPA's online calculator that helps architects, engineers, and property owners and managers assess the energy performance of commercial building designs and existing buildings"), a member of the project team enters several inputs: building location, space types and areas, operating hours, number of occupants, number of computers, area cooled, area heated, target score or energy use reduction, and estimated fuel use from each fuel source. The program provides the user with several outputs: an energy performance rating from 1-100; energy reduction due to intended efficiency goals; source energy intensity; site energy intensity; total source energy; total site energy; total annual energy costs; CO_2 emissions; and CO_2 emissions reduction due to intended efficiency goals.[63]

One notable difference that sets Energy Star apart is that it requires commissioning before the building can be certified, soon after occupancy. The Energy Star rating system does not require building modeling, which makes it substantially less expensive than LEED. Additionally, there is no cost to certify a project. The only fees a project would incur would be the cost to get the application verified and stamped by a PE or RA. Usually, this can be taken care of by someone in-house, so the cost would be minimal.

Green Globes

Green Globes, a project of the Green Building Initiative (GBI), is marketed as a more affordable[64] alternative to LEED that evaluates buildings in 7 categories: Project Management, Site, Energy, Water, Materials & Resources, Emissions, and Indoor Environment, for a total of 1,000 points. Unlike LEED, Green Globes has no prerequisites; projects need only score a minimum of 35% of the total applicable points, be larger than 400-square feet, and have been occupied for less than 18 months. The rating system consists of online software tools and best practices guidance and provides access to qualified assessors. The program offers multiple options for achieving high levels of energy performance and conducting comprehensive life-cycle assessment calculations.

The most recent edition of the rating system (released in June 2013) is now based on the American National Standards Institute (ANSI)/Green Building Initiative 01-2010: Green Building Assessment Protocol for Commercial Buildings standard, and has an increased focus on energy and materials and resources.

Some find Green Globes to be an easier rating system to deal with. Green Globes addresses some aspects of sustainability, like life-cycle assessment, more than LEED, and is more adaptable to the parameters and locale of each unique project:

> *I was pleasantly surprised by the ease of use of the online project assessment tools and also by the system's flexibility, adaptability and transparency. One immediate surprise was that credits could*

> *be considered 'Not Applicable,' a feature absent in LEED. An additional pleasant surprise was the excellent customer service...each project was assigned a third-party Assessor who is also the person to whom questions regarding greening strategies, grey areas, and other questions can be posed and resolved in the flow of the design and construction processes. Unlike LEED where a technical inquiry costs $330 and takes 4 weeks for a response, the Assessor provides the answers quickly and at no cost.*[65]

The one issue with Green Globes is its lack of market share, which in turn would affect the branding opportunities of a building project. In a 2012 study by the U.S. Department of Energy that compared LEED, Green Globes, and the Living Building Challenge, Green Globes was reported to only have 2,847 registered and certified buildings, compared to LEED's 41,696. However, Green Globes aligned with more of the Federal requirements (25) than any other new construction system in the review, while LEED 2009 aligned with only 20.[66]

National Green Building Standard (NGBS) / National Association of Home Builder's (NAHB) ICC 700

Developed by the International Code Council (ICC) and NAHB, this standard is designed for residential construction, namely new homes (including multifamily buildings), as well as hotels, dormitories, and residential land developments. There are 4 levels of certification: Bronze, Silver, Gold, and Emerald; Emerald-certified residences incorporate energy savings of 50% or more over national model codes.[67]

ASHRAE bEQ

The ASHRAE Building Energy Quotient (bEQ) rating program provides certification for buildings that achieve labels from B (Efficient) to A+ (Net Zero Energy). The bEQ label is actually two labels: an In Operation label and an As Designed label. bEQ is "an easily understood, yet technically sound, tool for understanding a building's energy use and identifying opportunities to reduce that use [as] needed."[68]

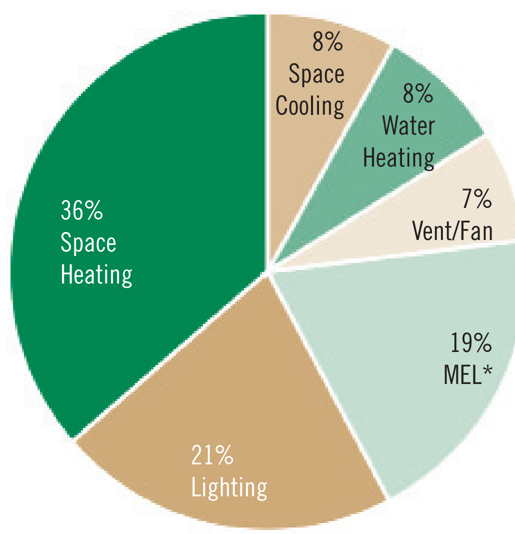
Similar to Energy Star Target Finder, it utilizes information from 2003 CBECS data for the baseline building. The proposed design is modeled using ASHRAE 90.1-2007 and the energy performance is measured as a reduction in EUI.[69] The main difference between bEQ and Energy Star is the addition of an Energy Audit and the required use of ASHRAE-certified building assessment professionals: a certified modeler and certified assessor for the two portions of the label. The costs of bEQ are minimal, and much lower than LEED or Green Globes.

Outcome-Based

The most comprehensive type of rating system, outcome-based programs consider the whole building's energy use over a 12-month period, including end uses like plug loads, which can account for a surprisingly large portion of a building's energy use (see figure). These systems are flexible, allowing for multiple pathways to accomplish performance goals.

These standards are relatively new, and are therefore

Typical Energy Use for a Commercial Office Building: National Average



*MEL - Miscellaneous Energy Loads (Plug Loads)

Chart recreated based on data from *Comparative Analysis of Prescriptive, Performance-Based, and Outcome-Based Energy Code Systems.*

not widely adopted at this time. They also require more effort than the other types of standards, as they require testing, calibration, and commissioning of many building elements to verify performance, which can be cost prohibitive.[70]

Living Building Challenge

Developed by the Cascadia Green Building Council and housed under the International Living Future Institute, the Living Building Challenge (LBC) is one of the most stringent green building rating systems in existence, with only 6 projects achieving Full Certification to date. Realizing this, the ILFI introduced 2 other certification levels, Petal Recognition and Net Zero Energy, in the past few years.

LBC is comprised of 7 petals: Site, Water, Energy, Health, Materials, Equity, and Beauty, which are broken down into a total of 20 imperatives.[71] Petal Recognition is achieved if a project adheres to at least 3 of the 7 petals and Net Zero Energy certification is achieved if a project adheres to the Energy petal. Certification is a two-part process, like bEQ and Energy Star, in which an audit is conducted 12 months after occupancy. The cost of LBC is similar to that of LEED certification, if not a little more expensive, but is again based on a project's square footage.

The Materials petal's Red List and strict distance requirements for the sourcing of building materials present a unique challenge for design teams. The Red List forbids the use of a wide range of harmful, toxic, and carcinogenic materials, including PVC, formaldehyde, lead, mercury, and phthalates. The Red List presents a large expense of time and effort for those seeking LBC certification.

> "People just don't know how materials fit together—and that includes the manufacturers.' For the Tyson Living Learning Center, a Living Building in Missouri, "We had two people on the phone for four months, checking on the materials," says Daniel F. Hellmuth, AIA, LEED AP, principal at Hellmuth + Bicknese, St. Louis.[72]

Early adopters face many challenges; LBC has a steep learning curve, and first-timers may not get fully compensated for additional work and time put in. LBC's highly experimental nature also leads to higher up-front costs. "It's called a challenge for a reason," says the ILFI's Skip Brukman. "But it's not the Living Building Impossible."

Building Owners and Managers Association International (BOMA) 360

BOMA 360 is a program that evaluates existing buildings over the following categories: operations and management, life safety, security, risk management, training and education, energy, sustainability, and tenant relations and community involvement. Fees for certification are close to those of bEQ.

Nearly 600 buildings have been certified since BOMA 360's inception in 2009, and tenant surveys report high satisfaction in 52 out of 54 categories. 92% of tenants report high overall satisfaction with BOMA 360-certified buildings.

SBTool

Less of a rating system, and more of a rating system *toolbox*, SBTool can be used by design teams to develop a personalized rating system for the variety of local conditions and the project's specific building type. It can also be used by owners and managers to communicate their sustainability goals to the design team. The program handles all phases of the design and construction process and is applicable to both new construction and retrofits, and buildings up to 100 floors in height with up to 5 occupancy types.

The system allows third parties to establish parameter weights that reflect the varying importance of issues in the region, and to establish relevant benchmarks by occupancy type, in local languages. Thus, many versions can be developed in different regions that look quite different, while sharing a common methodology and set of terms. The main advantage, however, is that a SBTool version developed with local knowledge is likely to be much more relevant to local needs and values than other systems.[73]

SBTool's software is completely open source and free to users. An additional advantage is that the rating system, once created, can be reused repeatedly for multiple projects and can be altered by project members at any time.

Green Building Codes and Standards

ASHRAE 90.1-2010: Energy Standard for Buildings

ASHRAE 90.1 serves as a minimum standard for the energy efficiency of buildings and building components. It covers requirements for the building envelope, HVAC equipment, lighting systems, water heating, building process loads, and electrical systems and considers the cost effectiveness of all items included in the code. It is updated every three years by multiple groups of stakeholders and ASHRAE committees; manufacturers, designers, code officials, and trade organizations all provide input for changes.

Appendix G was added to the 2004 update of 90.1 to respond to the need for acknowledgement of green measures—building orientation, natural ventilation, daylighting, and efficient HVAC system selection—created by systems like LEED. Appendix G provides specific guidance on the rules to use and procedures to follow when simulating building energy use to substantially exceed the requirements of 90.1. It is especially useful for generating energy simulations in order to achieve LEED credits and energy tax credits. 90.1-2010's goal was to provide a 30% reduction in energy use over 90.1-2004. ASHRAE intends the 2013 edition of 90.1 to achieve a 40% improvement.[74]

ASHRAE Standard 189.1-2011: Standard for the Design of High-Performance Green Buildings

189.1 is not a design guide or a rating system. It is primarily based on the mandatory requirements (with some elements allowing a choice between a prescriptive or performance option) that establish baseline criteria for a high-performance green building found in voluntary rating systems. The standard provides guidance on the subjects of site sustainability, water use efficiency, energy efficiency, indoor environmental quality, the building's impact on the atmosphere, materials, resources, and construction and operations plans. A key advantage of 189.1 is its addition of process loads (including plug loads) into energy calculations.

189.1 provides two options for compliance: a prescriptive path and a performance path. Compared to 90.1-2007, the U.S. DOE determined that applying the minimum set of prescriptive recommendations of 189.1-2009 resulted in weighted average site energy savings of 27%. 189.1-2011's goal was to increase energy efficiency by 5-15% when compared to 189.1-2009.[75]

International Green Construction Code (IgCC)

A collaborative effort of the ICC, USGBC, AIA, ASHRAE, the American Society for Testing and Materials (ASTM), and the Illuminating Engineering Society, the IgCC was released in 2012. The IgCC is administered by local code officials as an overlay on existing construction and energy codes, to establish "baseline regulations for new and existing buildings related to energy conservation, water efficiency, building owner responsibilities, site impacts, building waste, and materials."[76] Additionally, 189.1 is offered as an alternative path to compliance with the IgCC.

The IgCC requires performance that is 30% better than the 2006 International Energy Conservation Code and requires use of plumbing fixtures with fitting flow rates reduced by 20% compared to International Plumbing Code. The code also mandates commissioning and provides material sourcing and IEQ provisions as well as requirements for enhanced water and energy performance.

The IgCC is flexible, allowing governmental jurisdictions to ramp up or require enhanced performance in many areas. The jurisdiction may choose a number of electives from a list of 60, including options such as brownfield redevelopment, reduced light pollution, reuse of non-potable water, and so on.

As a code, compliance is determined once final inspections are completed; there is no requirement for post-occupancy energy and water usage reporting, no possibility of decertification, and no third-party approval process.

Trends in Rating System and Code Adoption

In the past decade, there has been a marked increase in the voluntary adoption of, and recently, mandatory adherence to, green building rating systems, standards, and codes. LEED has been adopted in some way by at least 35 states, 58 counties, and 384 cities, while Green Globes has been adopted by at least 23 states, 15 counties, and 3 cities. Together, LEED and Green Globes have been used as either guides or requirements for over 20 federal agencies and almost 600 federal buildings.[77]

The U.S. government has been a role model for private industry; the General Services Administration adopted LEED as their rating system of choice in 2000, and has required all new federal buildings and renovation projects to achieve at least LEED Gold. This governmental commitment to green building has caused a trickle-down effect on both private buildings' certification rates and professionals' pursuit of accreditation.

A 2012 study conducted by the Harvard Business School collected data on 735 California cities from 2001 to 2008, including LEED registrations, construction starts, and demographic information like population, median income, and measures of environmentalism (such as support of environmental political policies and ownership of energy efficient cars). This study found that after local governments made commitments to pursue LEED certification for public buildings, there was an increase in professional LEED accreditation. Also, cities that adopted green building policies for municipal buildings had 90% more private sector green buildings by 2008 when compared to cities of similar size, demographics, and environmentalism. Neighboring cities also saw an increase in private and public sector LEED building applications. The public sector accounts for one third of the nation's construction spending, so it holds considerable influence over the increasing acceptance and design of green buildings.[78]

Greater incorporation of sustainability into mainstream building requirements can be a good thing for the U.S., but it is already receiving significant opposition from private industry groups. In order to reach the goals of the 2030 Challenge, environmental advocates have pushed for increasingly stringent energy requirements to be included in newer editions of IECC and ASHRAE 90.1. Codes, which are meant to serve as a minimum standard or base level of building performance, are now becoming more akin to all-prerequisite rating systems, leaving project teams no choice in the matter of their personal sustainability goals and the methods to accomplish them. "Codes set the floor and rating systems set the ceilings," Brendan Owens of the USGBC said after ASHRAE 189.1 was released; many construction industry professionals feel that this statement is no longer holding true.

"Evidence in most states indicates that staggering rates of non-compliance, as high as 100 percent in some jurisdictions, have eroded the gains from code development and adoption. Lack of resources, education, and political will are frequently cited causes of non-compliance."[79] Nationally, if states were to increase code compliance, the lifetime savings of 5 years of code-compliant construction would amount to $12-37 billion dollars, which amounts to an energy savings of 653-2000 trillion Btu.

An interview with Tim Ryan, Code Administrator for Overland Park, Kansas revealed the following issues with green codes in the U.S.:

> *There's been a push for the last couple cycles to increase the stringency and the volume of codes dealing with energy. The biggest problem you're running into right now is that [the increased restrictiveness of codes and impact on cost of construction due to these changes] is getting very political. There's been a big push back from home builders, commercial builders, and jurisdictions to these stringent energy codes. NAHB, BOMA, and others are coming out strongly against any new restrictive provisions.*
>
> *Enforcement agencies that have been trained in life safety (structural stability, fire safety, egress, sanitary conditions, air quality) are now expected to deal with issues of energy efficiency. Now they need more resources to enforce the codes, despite the fact that their departments have been experiencing layoffs over the past years. To enforce the codes, they need more resources.*
>
> *The 2012 energy code is more than double the size of the 2009 code. Building departments have concurrently been halved. Most jurisdictions that have adopted the 2012 code amended it. [Overland Park] had to roll back R values for ceilings and walls and had to roll back air changes per hour (ACH) for blower door tests due to pressure from building industry. The old code says 7 ACH, the new code says 3, and so most places adopt 5. We need the middle of the map, not provisions that are so restrictive that the politicians refuse to adopt them.*
>
> *If you take all of the codes that ICC publishes, between 2006 and 2012 edition, the entire volume of codes has increased by almost 900 pages. Another 120 standards were added. Look at a typical jurisdiction; they are one-man, two-man operations enforcing codes. Every day I come to work, I have 3000 pages of regulations to enforce. You have to pick and choose; it's risk management. Energy codes have lower priority. It may be a long-term quality of life issue, but it's not pressing.*

As of July 2013, the IgCC has only been adopted by 5 states and 2 local governments. The International Building Code's 2012 edition has only been adopted by 6 states (in its entirety), 3 states (with limitations), and 2 states (adopted, but not yet effective). 26 states use IBC-2009, and 11 still use IBC-2006.[80]

To achieve certification, the use of integrated project delivery is integral.

The Institute of Market Transformation hopes to encourage increased code compliance by educating architects and engineers on how to comply with the new codes effectively. This involves the creation of a "simple building manual," which helps design professionals working on smaller projects use stripped versions of the code that only include sections that pertain to small projects. They are also working on brochures to explain how existing codes apply to renovations, retrofits, and repairs. To aid code departments, they provide case studies to profile best practices on enforcing the energy codes.

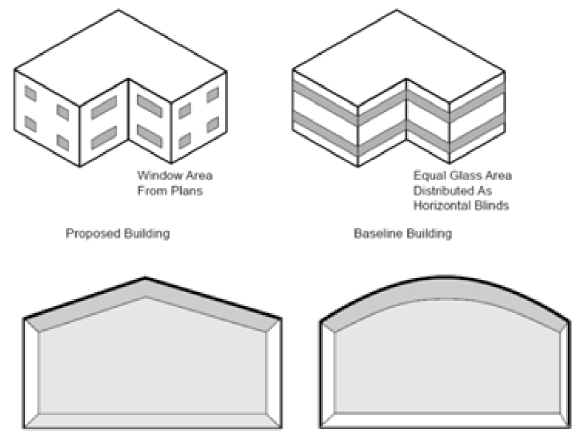
Effect of Project Delivery Methods

To achieve certification, the use of integrated project delivery is integral. For rating systems like LEED and LBC, it is almost imperative if a project is committed to achieving a specifically high level of performance. The linear design process doesn't work anymore: "If you try to do an energy efficient building in your traditional path, you're just adding things to the cost that you can't afford," remarked Kent Duffy of SRG Partnership Inc. By convening as a team early and often, determination of performance goals and design strategies is front-loaded and systems can be selected and organized in a synergistic way.[81]

Jerry Yudelson states that in order to achieve a high-performance building, the project must have an integrated design process. Also, every building team member should share in the risk of failing to achieve the project objectives. Ways to effectively spread liability among project participants are discussed in "**Managing Liability through Smart Contracts**" later in this paper.

Risks Unique to Sustainable Buildings

Sustainable buildings can mitigate risk in certain ways: high-performance electrical, plumbing, enclosure, and HVAC systems are safer; commissioning brings an independent third party to certify correct installation and operation of building systems; and retrofitting older buildings improves occupant health and safety. Although many green improvements are intended to provide only benefits:



Basic model renderings that simplify building geometry for energy simulation. Source: *User's Manual for ANSI/ASHRAE/ IESNA Standard 90.1-2004*.

> *Vegetated roofs, new and untried technologies, misapplication of proven techniques in new situations, unprotected storage of recycled material, solar PV panels (especially in remote areas), new forms of alternative energy generation and storage, and other emerging green practices present a new generation of risks that insurers need to understand.*[82]

The following section provides several examples of risks characteristic of green buildings.

Energy Performance and Building Energy Modeling

Model vs. Reality

In order to generate a building model, the real-world characteristics of the building are modified in order to make energy calculations easier. Windows, instead of being individually modeled, are simplified into bands of continuous glazing. A complex building geometry, like the curved plan on the right of the figure, would be replaced with a simpler geometric rendering, like the pentagon on the left. Structural assemblies are also kept in their most basic form: "The baseline building is assumed to be steel framed no matter what the construction of the proposed building."[83] Complex forms of heat transfer are neglected from energy calculations due to their complexity and the inability of modeling software to perform fourth-order differential equations. Models also assume that all building elements and systems are installed correctly and will perform perfectly. Site-specific climate characteristics and local weather data can be entered into a model, but are still generalizations for the future conditions that the building will actually experience.

These sorts of alterations and assumptions allow for the creation of a model that does not require days of data entry and rendering. Due to these changes, half of buildings' models' energy projections can deviate by as much as 25% from their actual buildings' energy usage.[84] For these reasons, building models are not grounded in reality—they are just predictions—and therefore cannot be relied upon and treated as a realistic representation of the actual building.

Owner Expectations

With the manner in which building simulation is marketed currently, it is not surprising that many building owners have unrealistic expectations for the accuracy of models and their performance predictions. In the early years of modeling, some design professionals would make lofty claims that modeling prevents delays and change orders.

If an owner or developer relies on these types of claims, and is not properly informed and educated, they may misconstrue outputs from a model as promises for future performance and expect an idealized construction schedule and budget. Many owners also focus solely on the potential for enhanced performance, but do not recognize the possibility of calculation mistakes or model shortcomings that result in the failure to attain sustainability goals. Owners may also claim to be unsophisticated and unknowledgeable, relying on the design professional to explain the entire building energy modeling process. Frank communication is key to prevent claims from an uninformed owner; see the upcoming section, "**Managing Liability through Smart Contracts**," for tips on effective communication with clients.

Moisture Issues

Several green strategies for buildings, especially those that are recommended for buildings seeking certification, may introduce moisture into a building, which can wreak havoc in a many ways, from mold growth to loss of structural integrity.

> *New designs may advocate for a tighter building envelope or increases between exterior and interior circulation which exceed HVAC industry standards—either of which may lead to moisture and mold issues. Other practices relevant to LEED credits and 'best practices' such as building flush-outs may also contribute to an increased risk of mold given the large amounts of outdoor air and moisture introduced into a building.*[85]

Building materials new and old, synthetic and natural, all pose unique risks for buildings. Use of untested, new materials and reuse of existing building materials may lead to moisture intrusion. "We believe that it is reasonable to assume that if we are relatively unfamiliar with a new material's individual performance then we probably know even less about the material's interaction with other adjacent components."[86] Materials that have little to no field testing have an inherent risk associated with them. Additionally, reuse of existing materials may introduce unexpected moisture through unexpectedly water damaged or mold contaminated materials. Mixed use of synthetic and natural materials may create the potential for condensation and moisture entrapment.

The implementation of vegetated roofs can also be problematic. Moisture may migrate or become concentrated in-between impermeable membranes due to incorrect installation or maintenance. The hydrostatic head caused by soil retaining water constantly may also cause moisture intrusion into the roof assembly and condensation in unexpected areas.

Excessive natural ventilation through use of operable windows can lead to untreated, humid outside air, and worse, precipitation, to enter the building. Use of automated sensors or overrides should be considered to ensure windows are not left open for extended periods of time.

Green rating systems, like LEED, often require increased ventilation to maintain a higher standard of indoor air quality. Higher air changes per hour may lead to depressurization and introduction of humid outside air and pollutants into the building envelope.

Pre-occupancy "flush-outs," a green strategy for removing indoor air pollutants emitted by adhesives, paint, and carpet, are another source of unwanted introduction of moisture into the building interior. The flush-out process takes a minimum of 7 days, and as long as 30, in which the HVAC system is run continuously, 24 hours a day, with 100% outside air conditioned to maintain normal indoor temperatures.

In order to reduce heating and cooling loads, green rating systems often specify higher R-values for building envelopes. Increased insulation in walls can change the wall system's performance and may cause condensation to accumulate on the wrong side of the vapor barrier.

Green rating systems often award credits or points to the green strategies mentioned above, but often do not consider regional climatic differences. Projects planned in humid areas should be careful with their implementation of flush-outs, operable fenestration, and high levels of insulation. To combat introduction of humid air, construction filters should be installed in air handling units before a flush-out and then replaced after it is complete. Green roofs require proper design, installation, and tenant maintenance in order to avoid water intrusion problems. Best practices for building enclosures are: a) use water resistive barriers; b) install secondary barriers for redundancy; c) design drainage planes to channel water down and out of the envelope; and d) design proper flashing and sealant joints.

Avoid pressure imbalances by ensuring the correct distribution of air flows within the building. Use monitoring equipment to track indoor air quality conditions over the first year of occupancy to verify performance. Adequate and site-specific commissioning should be conducted to prevent problems from worsening and damage occurring.

> *The building envelope needs to be commissioned in a manner that would avoid rainwater leaks, excessive air leakage, and condensation problems. In cases where the envelope is commissioned, both individual envelope components (like windows) should be tested as well as assemblies of multiple adjacent components. Testing individual components does not address the connection points and intersections between various envelope components where most of the failures occur. Assembly testing can include a mix of qualitative and quantitative testing, such as ASTM tests.*[87]

Hire a waterproofing consultant to conduct testing; do not take responsibility for these tests as it is usually outside the scope of a design professional's expertise.

Innovative Products, Materials, and Strategies

Innovative design is one of the cornerstones of sustainability, but with it comes uncertainty and potential exposure to risk and increased liability.

> *While laudable, the use of novel less harmful building material or new construction techniques may give rise to liability due to: (i) contractor inexperience with installation; (ii) lack of long term evaluation of green materials; (iii) lack of understanding of how new building materials may impact existing traditional building systems, or (iv) warranties provided unintentionally about the durability or effectiveness of unproven materials or techniques.*[88]

The unproven nature of many new building materials, processes, systems, and elements is exacerbated by the probable lack of data on the interaction of said products. Their performance in a variety of climates may also not be verified.

> *Although many of these products have been developed within the last five years, they are intended for use in buildings that should last for 50+ years. Even a casual review of the literature indicates that some of these products appear to have minimal in-situ testing or performance verification. Additionally, many of these products have not been marketed in a manner suggesting caution about regional or climatic restrictions in their use. Finally, we suspect that these has been even less testing of the complex, interrelated assemblies in which these products will be asked to co-exist for the next half century or more.*[89]

The brunt of the risk imposed by these innovative products rests on the shoulders of the design professional. Often, this risk is not correlated with an increase in compensation.

> *Modern day design professionals are constantly expected to find new ways of building projects better, faster, cheaper, and greener, while at the same time they are too often viewed as professionally and financially responsible if those new methodologies and materials do not succeed to the full extent of their hoped-for results.*[90]

The introduction of untested green products may result in schedule delays, unexpected expenses (if an anticipated release of a new product is delayed, or if an alternate product must be selected), and system interaction issues (if the contractor realizes a product is not feasible only once installation is attempted).

The practice of recycling "greywater"[91] to irrigate landscaping may also present risks if methods to prevent contamination are not rigorously practiced. An incident involving recycled greywater polluting a water play area resulted in several deaths and substantial claims against the design team.[92]

Novel forms of energy generation and storage can also present problems if the systems are not installed or maintained correctly. The investment in solar photovoltaic (PV) panels, geothermal preheating and cooling systems, wind turbines, and other costly renewable energy installations may have a payback period of over a decade, depending on the size of the system and the locality in which it was installed. For instance, a solar array may turn out to perform poorly due to a high number of overcast days, and a wind turbine may not generate as much power as predicted due to lower wind velocities in its installation vicinity. These issues may cause a frustrated building owner to seek recompense through filing claims against the design team.

Since green building certifications are bestowed upon projects by third parties, design professionals cannot guarantee that a building will achieve a certain level of certification, or even that it will achieve certification at all.

Green Certification

Since green building certifications are bestowed upon projects by third parties, design professionals cannot guarantee that a building will achieve a certain level of certification, or even that it will achieve certification at all. "The use of third party rating systems introduces risk because of [the rating system organization's] lack of contract privity between the owners, designers, or contractors. Depending on the contract language used, participants on green construction projects may be bound to promises they have little control over."[93]

The delay between registration and certification may also lead to claims against the design team: "The typical green building project has a two year timeline from initial registration to final certification and between 25-30% of projects seeking certification never attain it."[94]

There are also discrepancies between realized lower operating costs and the level of green certification attained. Smaller Silver rated buildings have lower assessed and market values than other LEED-NC rating levels, while medium and large-sized LEED-EB properties at Silver and Certified levels are valued at the highest level of both assessed and market value per square foot.[95] A design professional may mistakenly imply a specific savings from operating costs or increased profit from higher rents that can vary depending on the level of certification attained.

The real estate industry has yet to fully realize the value of green buildings. Real estate brokers and valuation professionals have yet to fully acknowledge a correlation between sustainable buildings and higher market value; therefore, an owner hoping for a higher sale price for a new green building may not fully realize the benefits they were expecting.

The general population still does not completely understand green building ratings, and chances are that owners and developers may misunderstand their meaning as well. As with modeling, building owners, developers, managers, and tenants may have unrealistic expectations for the performance, operating costs, and appearance of the completed project because they know it is a certified building. Projects can achieve green certification in many ways, and each sustainable building behaves, feels, and operates differently.

Missed Financial Opportunities

Tax incentives with the specific purpose of encouraging sustainable construction are a great way for project teams to recoup the investments spent on more costly green design alternatives. Conversely, an owner who wants to achieve these financial opportunities who has a project team that fails to fulfill their documentation and submission requirements in a timely fashion, resulting in the financial benefit not being realized, may make a claim against members of the design team. This has happened in the past, when consequential damages were sought in response to the failure of responsible parties to account for the steps required to attain tax credits.[96]

Managing Liability through Smart Contracts

Sustainable Standard of Care

> *Traditional standard of care is generally based on the performance of others. The external performance focus works well where the project and its tasks utilize industry standards that have been used before and have a history of success and failure. Sustainability and building modeling bring about issues because they and their associated products and processes may never have been undertaken before and have no historical application.*[97]

The construction industry is experiencing a period of change currently; a crippling recession, increasing demands for sustainability from public and private clients alike, and a blooming new market for building modeling have all resulted in a new set of design and performance expectations for the design professional.

Sustainable design accreditation organizations, like the Green Building Certification Institute (GBCI)—a partner of the USGBC—whom confers LEED Green Associate and LEED AP status to professionals in the building field, may also be creating a perceived higher professional standard of care for those that they certify.[98] As more jurisdictions institute green building standards by code, the standard of care for design professionals may also begin to include sustainable design practices.[99]

When writing contracts, it is important to establish terms so the fact that the project is sustainable does not result in an increased standard of care for the design professional. The standard of care set forth in AIA B101-2007 SP includes a provision to explicate the architect's responsibilities:

> *The Architect shall perform its services consistent with the professional skill and care ordinarily provided by architects practicing in the same or similar locality under the same or similar circumstances. The Architect shall perform its services as expeditiously as is consistent with such professional skill and care and the orderly progress of the Project.*

If this provision is modified, it may have adverse consequences from both a legal liability perspective and an insurance coverage perspective. Heightened standard of care language such as "the Architect shall perform its services consistent with highly experienced green building or sustainability design professionals" may increase the architect's liability to the owner.

Warranties and guarantees pose significant risks that design professionals may inadvertently expose themselves to by committing to any of the following: a) attaining green building certification; b) attaining a specific "level" or amount of "points" with regards to green building certification; c) achieving a specific decrease in energy or water usage; d) achieving a specific cost savings due to lowered operating costs or higher tenant rent or building sale price; and e) achieving a qualitative benefit such as increased occupant health or productivity. Liability due to promises such as these are often excluded from professional liability insurance coverage.

Defining the scope of the design professional's design phase, construction phase, and sustainability services is highly recommended; AIA D503-2013 provides precise language for doing so. This document is covered in greater detail in the "**Contract Documents**" section of the paper.

Educate and Manage Expectations

An informed owner that is offered all opportunities to approve or reject design considerations is much less likely to file claims once the building is completed and occupied. For this reason, it is imperative that a design professional's client and all members of the project team are actively informed of all sustainability objectives, and how those goals are to be met. Charrettes are a great method to achieve this; meetings such as this should occur early and often. These workshops allow the project team to brainstorm optimal green strategies and can be an opportunity to bring together the design team and members of the community so they may voice their concerns and desires.

Some clients may wish to attain sustainability goals or utilize green building strategies without fully comprehending the amount of time and effort that is required. The project's design professional must bear the responsibility of educating the client and ensuring that they approve of every design decision made for the project. They must reach a mutual understanding as to the client's desires, objectives, and tolerances. The client should understand that electing to design and build a high-performance building, and/or achieve green certification, will have impacts that they must accept as their choice and risk, not the design professional's:

1. Pursuance of green building certification can be uncertain, time-consuming, and expensive, and the design professional must be paid accordingly for time spent working on documentation.

2. Actual building performance may not meet expectations.
3. Sustainable products may extend construction schedules.
4. Green standards and products may change over time.
5. Sustainable construction requires participation by others, especially the contractor.
6. Sustainable projects require actions in operation and maintenance which are post-construction and not the design team's responsibility.[100]

Providing this list of caveats may spook a risk-averse client, but it is much better for them to be aware of the worst-possible outcomes than to naively pursue a sustainable project without a good idea of the risks involved. To provide a client with the big picture, offer them a variety of building case studies that are similar to the envisioned project. Pinpoint green strategies from these case studies that would be appropriate to pursue in the proposed building and offer insights on the benefits and drawbacks of implementing each one.

Importance of Written Records

To protect themselves from potential claims, design professionals should make a practice of documenting their entire decision-making, design, and construction process. Any correspondence with project team members, product manufacturers, certification officials, and others should be filed, and all agreements and approvals made by the owner should likewise be stored. Any and all visits to the construction site should be recorded, and the owner must be notified of any issues seen while on site. Project teams should keep written records of any research they have conducted during the course of the project. The project team must be specific about sustainability goals and how they plan to achieve them. Here are a few tips for keeping contract documents clear and comprehensive:

1. **Define terms**. Performance-based terms may be a viable alternative to LEED-defined goals, depending on the project. Do not use generic terms like "green," "sustainable," and "high-performance" without defining them in detail.
2. **Define timelines**. Sources have indicated up to a 3-year delay in attaining final certification; by clearly laying out the timeline (including extra time for documentation and material sourcing), unexpected delays and litigation can be avoided.
3. **Account for the regulatory environment**. All participants should be aware of the documentation and record keeping requirements for the third party rating system.
4. **Assign liability** according to responsibilities.
5. **Discuss and document waivers** for rights to consequential or liquidated damages.
6. **Define length and scope of obligations**. Designate whether a designer or contractor is obligated to remain on a project until certification and/or a tax incentive is obtained or not.[101]

Manage the unexpected outcomes of innovative products by completing these steps during the contract process:

1. **Verify that the client understands the risk**. Document the owner's acknowledgement that the new or innovative products, technologies, or methods chosen lack a proven history of successful application. As such, they are being incorporated into the project in order to accomplish recognized objectives, but that due to their innovative nature, there is a significant possibility that they will not realize those objectives or have collateral consequences.
2. **Obtain owner approval**. Identify the objectives of the product, and why they are being proposed over a traditional product. Confirm that the owner has weighed the relative risks and rewards, and will accept the risks in order to incorporate the innovation into the project.

3. **Do your duty, but no more than necessary.** Document and verify the level of investigation and analysis, and include a statement that the limitation of the design professional's obligation for the performance has been fulfilled.

Contract Documents

D503-2013, *Guide for Sustainable Projects*

This guide provides an in-depth discussion of the AIA Sustainable Projects documents, as well as the LEED-specific B214 form. It also provides a host of very useful definitions for the more vague terms involved in the design and construction of sustainable buildings. D503 also explains the process for conducting a "Sustainability Workshop" (similar to a charrette).

The 2013 version, an update to the 2011 version of D503, goes into more detail about drafting a "Sustainability Plan" by itemizing each "Sustainable Measure," noting their point/credit requirements, delegating responsibilities to a specific party in the project team, and explaining how the Measure will be attained and verified:

> *...the Parties should consider how achievement of each Sustainable Measure is going to be verified. The Sustainability Plan can be used to establish performance parameters that will demonstrate achievement of each Sustainable Measure, the types of testing necessary, and the party responsible for verification that those performance parameters have been met.*[102]

Each Sustainable Measure is described in detail, to reduce the potential for confusion:

> *[Describe] the implementation of strategies selected, the specific details of design reviews, the testing or metrics necessary to verify achievement of the Sustainable Measure, and a description of the Sustainability Documentation required to be submitted for the Sustainable Measure.*[103]

D503 also addresses claims and disputes, specifically encouraging the waiving of consequential damages:

> *Consequential damages on any particular sustainable project could conceivably include, among other things, unachieved energy savings, unintended operational expenses, lost financial or tax incentives or unachieved gains in worker productivity.*[104]

This document is flexible and adaptable for use to pursue third-party green certification, to conform to code requirements, or to just keep track of owner-approved sustainable goals.

ConsensusDocs 310

The ConsensusDocs family of contract documents provides for many different types of projects, but the primary one that addresses green building is 310, the *Green Building Addendum*. A unique element of the *Addendum* is the introduction of the "Green Building Facilitator" (GBF), who can be the design professional, contractor, construction manager, or even a third-party consultant. The addition of the GBF position takes into consideration the greater need for coordination on green building projects. The GBF's main function is to address the use of new materials, equipment, and design components and to perform resolution procedures by counseling the owner on product alternatives and addressing objections from the project team.

The *Addendum* also addresses consequential damages:

> The addendum states that the client's loss of income or profit or the client's inability to realize potential reductions in operating, maintenance, or other related costs, taxes, or other similar benefits or marketing opportunities resulting from a failure to attain the elected green status or intended benefits to the environment are consequential damages. Therefore, if the underlying contracts for design and construction waive the client's right to consequential damages, the design firm and the construction team are not at risk for what could be significant losses that are not directly related to their performance.[105]

Similar to AIA D503, the *Addendum* clarifies responsibilities and describes sustainability goals through "Elected Green Measures" and verification of their "Green Status." The *Addendum* is also flexible, allowing for use when pursuing different types of green certification, and can be added to any contract document.

Additional Contract Documents

The aforementioned contracts are not the only documents available to help design professionals construct smart contracts. A few others are listed below:

- Engineers Joint Contract Documents Committee 2013 Construction Series
- A101-2007 SP, *Standard Form of Agreement Between Owner and Contractor, for use on a Sustainable Project where the basis of payment is a Stipulated Sum*
- A201-2007 SP, *General Conditions of the Contract for Construction, for use on a Sustainable Project*
- A401-2007 SP, *Standard Form of Agreement Between Contractor and Subcontractor, for use on a Sustainable Project*
- B101-2007 SP, *Standard Form of Agreement Between Owner and Architect, for use on a Sustainable Project*
- B214-2012, *Standard Form of Architects Services: LEED Certification*
- C401-2007 SP, *Standard Form of Agreement Between Architect and Consultant, for use on a Sustainable Project*

Best Practices for Design Professionals

Integrated Project Delivery with Constant Communication

Green projects have a much better chance of succeeding if the project team works together from the beginning, and if the owner is kept "in the loop" regarding all decisions. A collaborative approach to project delivery with early and active involvement by the owner, contractor, and design professional is highly recommended.

Green projects have a much better chance of succeeding if the project team works together from the beginning.

If the project team has aspirations to produce a Living Building, net zero, or very high-performance building, the need for a cooperative design process is even larger. Jerry Yudelson, author of many books on the subject of green building, recommends that in order to meet the 2030 Challenge, design teams must make LEED Platinum a BHAG (big, hairy, audacious goal) at the beginning of the project and have early-stage eco-charrettes with an involved owner.

Cautious Modeling

Owners should be made aware that building energy models are only hypotheses for the actual energy performance of the constructed building. The design team should explain to clients that models are simplified versions of the actual constructed building, and should present the energy calculations as a range of expected outcomes, not a promise for future performance.

Yudelson warns teams of neglecting plug loads: "Process energy, plug loads, commercial refrigeration, and other non-regulated energy uses were not included [in the ASHRAE and USGBC standards] because the codes did not establish a baseline for these end uses."[106] Therefore, in order to have a more accurate, representative model, plug loads should be included.

Smart Use of Innovative and Untested Products and Processes

When dealing with innovative products, the best practice is to strictly adhere to the manufacturer's instructions and guidelines, and to encourage the contractor to do the same. The design professional should independently investigate the product by interviewing the manufacturer, contacting references for past applications, and reviewing all product literature. Clarify that the design professional should *investigate* thoroughly, while leaving actual, independent *analysis and testing* to others. The more independent analysis performed, the more the designer becomes responsible for the ultimate performance of the product or process. Therefore, it is not recommended that the project team conduct any experiments or testing of their own without including provisions in their contracts to protect them from increased liability.

Design professionals should perform their due diligence by conducting life-cycle analysis for each green strategy to be implemented. They should also incorporate manufacturer instructions and guidelines into the design documents and get validation from the manufacturer themselves, if possible.[107] These guidelines, along with operations and maintenance instructions, should be included in a commissioning plan, which should be created with the owner and passed on to the final building manager.

Specification

> *In preparing specifications, the Architect should carefully consider, and be prepared to explain, the effect the Sustainable Measures will have on building systems and other aspects of the Project; how those building systems are intended to be operated in accordance with the design parameters; and the impact of building use and occupancy resulting from the utilization of Sustainable Measures. Identification of how the performance criteria or other required characteristic contributes to attaining a Sustainable Measure will provide guidance for substitution requests…*[108]

Installation

It remains the contractor's responsibility to ensure the correct installation of all building elements, but the design professional needs to be on site early and often in order to monitor installation and report problems to the owner.

Operations and Maintenance

Ensure that the building owner creates a commissioning plan for the project. This will help the end users of the building keep track of maintenance schedules and monitor system performance.

Sensible Pursuance of Green Certification

If an owner has specific sustainability goals for a project and wishes to achieve recognition for attaining these goals, offer a variety of options for green certification to ensure that they achieve recognition for the building's high performance. Weigh each rating system's characteristics: cost, time, requirements, and applicability. The owner should be consulted about what sustainability goals are most important to them; discuss which "credits" they would like to achieve. Make no guarantees or warrantees regarding the building's certification.

The design professional should ensure that they are compensated for the time they expend on the documentation process. To protect themselves from possible claims, they should also make use of green contracts that delegate responsibilities and liability.

Clear Understanding of Tax Incentives and Governmental Regulations

A design professional should endeavor to understand all governmental requirements and financial opportunities. They should research any public utility issues, potential tax credits, land use and zoning enhancements and limitations. This process should be documented, and an express disclaimer of any further duties of investigation should be given.

Resources for Effective Sustainable Projects

As the green building industry has continued to bloom, many governmental and private organizations have cropped up to provide educational resources for industry professionals. Below is a breakdown and explanation of some of the resources available to expand designers' knowledgebase.

AIA

Measures of Sustainable Design

- Enumerates 10 measures that the Committee on the Environment sees as major contributors to a comprehensive definition of sustainable design

179D: Energy Efficient Commercial Building Tax Deduction Allocation—A Step-by-Step Guide

- Provides guidance for designers on public commercial projects seeking tax incentives on achieving the 179D tax deduction

50to50

- Offers 50 strategies for buildings to achieve a 50% reduction in fossil fuel use
- Each strategy includes an overview of the subject, typical applications, emerging trends, links to information sources, and important relationships to other carbon reduction strategies

ASHRAE

Building Energy Quotient: ASHRAE's Building Energy Labeling Program

- Explains the two systems of the bEQ program, As Designed and In Operation
- Offers a list of benefits of using the bEQ label and includes an FAQ

Education and Certification

- Outlines the process for ASHRAE's 6 different certification programs: Building Energy Assessment Professional, Building Energy Modeling Professional, Commissioning Process Management

Professional, Healthcare Facility Design Professional, High-Performance Building Design Professional, and Operations and Performance Management Professional
- Lists ASHRAE's resources for online learning, training, and continuing education

Standards, Research, and Technology
- Provides links to ASHRAE's research reports, advanced energy design guides, and energy guidance publications
- Offers guidance on ASHRAE's standards

Athena Sustainable Materials Institute

Life Cycle Assessment Publications
- Lists several studies and reports on the life-cycle assessment of structural materials and products

British Columbia Construction Association

A Study on the Risks and Liabilities of Green Building
- An update to the 2011 study, with additional follow-up to the unresolved case studies from the 2011 report

Building Owners and Managers Association International

BOMA 360 Performance Program
- Offers information on the BOMA 360 certification program

Experience Exchange Report (EER)
- Allows access to BOMA's income and expense benchmarking resource, which covers over 900 million square feet of space across the U.S. and Canada
- Provides the essential data and analysis to evaluate a building's operational performance
- Allows access to data going back to 2008 in order to build more sophisticated trend analyses and to look at property performance over time

BuildingGreen

The High Performance Buildings Database (HPB)
- Provides case studies of projects ranging from homes and commercial interiors to large buildings and even whole campuses and neighborhoods
- May be certified green projects, or simply projects that have one or more notable environmental features

ConsensusDocs

Guidebook for ConsensusDOCS 310 Green Building Addendum
- Clarifies definitions of words used in the document
- Offers more information on the Green Building Facilitator, Green Measures, Risk Allocation, and more

EnergyStar

Portfolio Manager Overview

- Introduces the Portfolio Manager online toolset
- Provides different options depending on whether someone is using the Portfolio Manager for an existing or new building

Purchase Energy-Savings Products: Estimate your Potential Savings

- Estimates money and energy savings using Excel spreadsheets for: appliances, commercial food service equipment, consumer electronics products, heating and cooling products, lighting products, office equipment products, and more

Fireman's Fund Insurance

Green Risk Advisor

- Provides information on green buildings, sustainable operations, green insurance coverage, and aspects of design unique to green homes and schools

Go Green Toolkit

- A four-step program to help businesses self-evaluate their current building performance, compare against benchmarks, take action to incorporate sustainability goals into their business plans, and seek certification

Green Building Advisor

Strategies and Details

- Offers advice and guidance for strategic planning and construction of new or retrofit green housing projects

Green Building Alliance

DASH

- An online software program that seeks to develop a knowledgebase of building performance data
- Users can compare, analyze, and benchmark their buildings in order to make informed decisions about energy efficiency, occupant health, and building performance

HOK

The HOK Guidebook to Sustainable Design

- A reference guide that covers design strategies and provides checklists of issues to consider at each stage of the design process

Institute for Market Transformation

Green Lease Library

- Offers guidance on how to develop, negotiate, and implement green leases
- Lists the best practices for successful green leases
- Provides sample green lease language and templates

Internal Revenue Service

Deduction for Energy Efficient Commercial Buildings

- A detailed explanation of the tax incentives for energy efficient commercial buildings

International Initiative for a Sustainable Built Environment

SB Method and SBTool

- Lists the uses of SBTool and offers the many ways it is adaptable to each unique project

International Code Council

Codes, Standards, and Guidelines

- Provides detailed information on the development of the ICC codes
- Links to options for purchasing codes

International Green Construction Code

- Provides resources for navigating green building codes
- Links to IgCC publications and the most recent version of the code

International Facility Management Association

Sustainability "How-To Guide" Series

- 25-35 page documents detailing the step-by-step process for: using the Energy Star EPA Portfolio Manager, designing sustainable lighting, landscaping, water, food service, and data systems, achieving green building certification, and commissioning

International Living Future Institute

Living Building Challenge

- Presents information about the Living Building Challenge
- Provides case studies for examples of successful Living Buildings
- Offers guidance through handbooks and technical assistance

National Association of Home Builders

ICC 700 National Green Building Standard

- Explains the ICC 700 standard and links to publications

National Center for Healthy Housing

Research

- Provides links to research papers on indoor air quality, moisture intrusion, and materials

NIBS

Whole Building Design Guide

- An indispensable resource for project teams looking to achieve sustainability goals
- Offers guidance for design, project management, operations and maintenance, documentation, and navigating BIM

- Provides links to tools and resources for cost estimating, code compliance, energy analysis, life cycle analysis, and more

National Performance-Based Design Guide

- Designed to meet the 2030 Challenge
- A performance rating system that is similar to the EPA's P-100
- Point system is weighted to give emphasis to strategies that are the most effective
- Provides continuing education requirements for a commissioning certification program

High-Performance Building Data Collection Initiative

- Designed to fill the space left by CBECS
- Seeks to collect and disseminate data on a variety of high-performance building attributes, not just energy use

Passive Solar Heating

- Offers guidance for taking advantage of passive solar heating, applying the key design elements, and operating and maintaining a passive solar building
- Links to US Air Force guide to passive solar design

ProjNET

- Software designed to allow team members to exchange project information and coordinate with one another

BRIK

- An interactive portal offering free online access to peer-reviewed research projects and case studies on the built environment through all stages of a building's life

National Renewable Energy Laboratory

Handbook for Planning and Conducting Charrettes for High-Performance Projects

- A step-by-step guide for planning, developing, and conducting design charrettes

National Resources Defense Council

Building Green: From Principle to Practice—Build Your Business Case

- Offers ways for building owners to understand the business rewards of sustainable construction

New Buildings Institute

Buildings Database

- Compilation of projects that have demonstrated or predicted performance that is 30% above the 2003 CBECS average
- Provides detailed financial, energy, and design process information

Tools and Guidance

- Provides guides for optimizing daylighting, reducing plug loads, and choosing mechanical systems

Northwest Energy Efficiency Alliance's Better Bricks Initiative

Integrated Design: Tools and Resources
- Links to multiple resources to aid sustainability professionals looking to incorporate integrated design and project delivery into their project

Open Energy Info

OpenEI
- An online knowledge sharing community which provides energy-related information

Pennsylvania State University

Energy Efficient Buildings Hub
- Hosts a variety of sustainability research publications on the subjects of market information, modeling, retrofit strategies, education and workforce issues, and more
- Provides case studies

U.S. Department of Energy's Department of Energy Efficiency and Renewable Energy

Building Component Cost Community (BC3) Database
- A database of costs associated with residential and commercial buildings
- Provides cost data for the development of new energy code requirements
- Compares construction costs under different energy codes
- Provides cost data for life-cycle assessment of high performance building components

Building America Research Tools
- A repository of technical tools to support researchers and building industry professionals
- Allows for evaluation of building designs and performance and cost data

Building Energy Software Tools Directory
- Lists and explains over 400 building software tools for evaluating energy efficiency, renewable energy, and sustainability in buildings
- Provides information about each program's characteristics: level of expertise required, users, audience, inputs, outputs, computer platforms, programming language, strengths, weaknesses, technical contact information, and availability

Buildings Database
- Contains data on tens of thousands of existing buildings
- Provides several types of analysis tools

Database of State Incentives for Renewables and Efficiency (DSIRE)
- Comprehensive database of financial incentives and governmental policies that support renewable energy and energy efficiency in the U.S.

EERE Financial Opportunities
- Provides information about grants, awards, and financial assistance provided to businesses, industry organizations, and universities to increase the use of renewable energy and energy efficient technologies

Energy Independence and Security Act
- Outlines the goals and requirements of EISA 2007

Tax Incentives for Energy Efficiency Upgrades in Commercial Buildings

- Provides information about the tax deductions available to projects that improve the energy efficiency of commercial buildings

U.S. Energy Information Administration

Commercial Buildings Energy Consumption Survey (CBECS)

- Provides the information provided by the most recent CBECS survey of U.S. commercial buildings
- Data includes energy consumption and expenditures

U.S. Environmental Protection Agency

Greenhouse Gas Equivalencies Calculator

- Presents equivalent amounts of consumption of a variety of fuels to better understand greenhouse gas emissions
- Links to other online calculators to estimate greenhouse gas emissions for households, transportation, and waste

Performance Based P100

- An electronic matrix-style system for rating building performance
- Searchable by green "attribute"
- Requires verifiable measures of performance (like commissioning)

USGBC

LEED Professional Credentials

- Explains the different types of LEED professional credentials

LEED v4 User Guide

- Presents the changes made to LEED 2009 to create LEED v4

LEED-NC Scorecard Draft (v4)

- Enumerates the points awarded to each prerequisite and credit in LEED v4

The Green Building Information Gateway (GBIG)

- A database of green building project data specifically pertaining to LEED
- Data is broken down into Activities, Buildings, Places, Strategies, and Collections

World Green Building Council

The Business Case for Green Building: A Review of the Costs and Benefits for Developers, Investors, and Occupants

- A report that highlights the different benefits for a variety of stakeholders throughout the life-cycle of a green building

Yudelson Associates

Green Building Books and Resources

- A comprehensive list of books on the subject of green buildings
- Provides case studies, anecdotes, and data

Endnotes

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[5] National Academy of Sciences, *Energy-Efficiency Standards and Green Building Certification Systems Used by the Department of Defense for Military Construction and Major Renovations,* Washington, D.C., National Academies Press, 2013, **www.nap.edu/catalog.php?record_id=18282**.
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[8] They do. *See,* Carrier's *Design Guide to Underfloor Air Distribution* and Addison and Nall's *Cooling via Underfloor Air Distribution: Current Design Issues and Analysis Options*.
[9] Building location, site, orientation, and structural, mechanical, and ventilation systems can all affect construction costs, whether the building is sustainably designed or not.
[10] These results were based on a study of 221 buildings, 83 of which were LEED® certified, 138 of which were conventional buildings.
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[17] Embodied energy is the energy required to produce a good or service. For example, a piece of steel rebar

has very high embodied energy. The iron ore must be harvested from the earth, transported to a smelting facility, processed, and then rolled into structural shapes. Furthermore, it must then be transported from the manufacturer to the reseller or directly to the contractor or project site, which adds to the CO_2 emissions of the project.

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