BUILDINGS ALIVE! ESTABLISHING THE COST OF LIVING BUILDINGS STRIVING FOR NET ZERO PERFORMANCE

Elizabeth J. Heider[1] and Clark Brockman[2]

INTRODUCTION

Innovative ideas have helped bring us some of the most incredible technological advances the world has seen. These ideas have ranged from the practical—"classic" inventions like the telephone—to the out-of-this-world. Who would have believed 15 years ago that today, in 2009, we are literally on the cusp of space tourism. As incredible as the thinking was behind those innovations, there is another element that affects whether or not inventions catch on in a meaningful way. As remarkable as many inventions are, we know that it takes more than innovation to bring big ideas into reality—it takes a deep understanding of what things cost, and of the value that objects or ideas will deliver over time.

We all have a telephone, but few of us will ever ride into space. And the reason behind this is simple: cost. Some mobile phone companies will give you a phone for " free" if you purchase an ongoing service plan and, by contrast, a ride on Virgin Galactic is likely to cost more than your home. Big, expensive, stretch goals benefit from challenges like the X Prize—the original competition that asked private entities to put someone into space and bring him or her home safely. This contest in particular, helped establish the baseline costs of private space flight.

Without costs, we cannot plan. We all might say we would pay for the opportunity to go to space, but without a tangible cost of doing so, we cannot possibly be sure, or sincere. Only when a cost has been estimated, can we budget and begin to make solid plans.

Unlike rocketing off into the ether, green building offers a bottom line return on investment. Green builders have already put together documented evidence of how quickly the upfront costs of building green can be recouped due to energy and resource savings—savings that have propelled the adoption of LEED standards for new construction by both public agencies and private real estate owners. But even a LEED Platinum building, as cutting edge as it is in today's market, still has a significant carbon footprint.

Enter the concept of a "Living Building," a facility that generates as much energy as it consumes and only uses as much water as falls on its site in a year. This has seemed to many to be an idea that is still quite far off. Assumed to be far too expensive to execute, Living Buildings have been considered "bleeding edge," if not altogether impossible, mostly because of misperceptions around first cost.

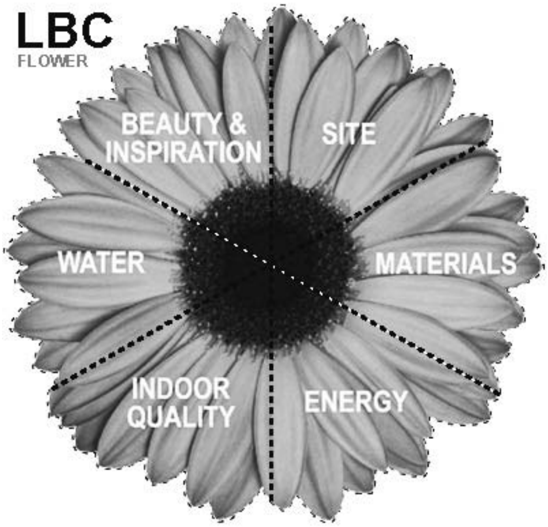
Without knowing what Living Buildings might truly cost and what return on investment they might provide, Living Buildings may have remained an after-dinner conversation topic rather than a discussion for the boardroom.

The task of changing cultural and social paradigms like these falls to those who are willing to disprove what is perceived as impossible. In the three years since the Living Building Challenge was announced—the green building industry's "X Prize"—there has been phenomenal interest from clients and design firms attracted by the elegance and simplicity of the concept and an appreciation for the new milestone it defines on the path toward a restorative future.

Often, the questions that arise after building owners begin to comprehend the magnitude of the Living Building Challenge are "What is the cost premium?" and "What might the payback be?" A study commissioned by the Cascadia Green Building Council, a chapter of both the U.S. and Canadian Green Building Councils, takes direct aim at those very questions, and the results are enlightening and encouraging.

[1]AIA, LEED AP, Senior Vice President, Skanska USA Building, elizabeth.heider@skanskausa.com.
[2]AIA, LEED AP, Associate Principal, Director of Sustainability Resources, SERA Architects, Inc., clarkb@serapdx.com.

FIGURE 1. LBC flower. For more information of the Living Building Challenge go to http://ilbi.org/.



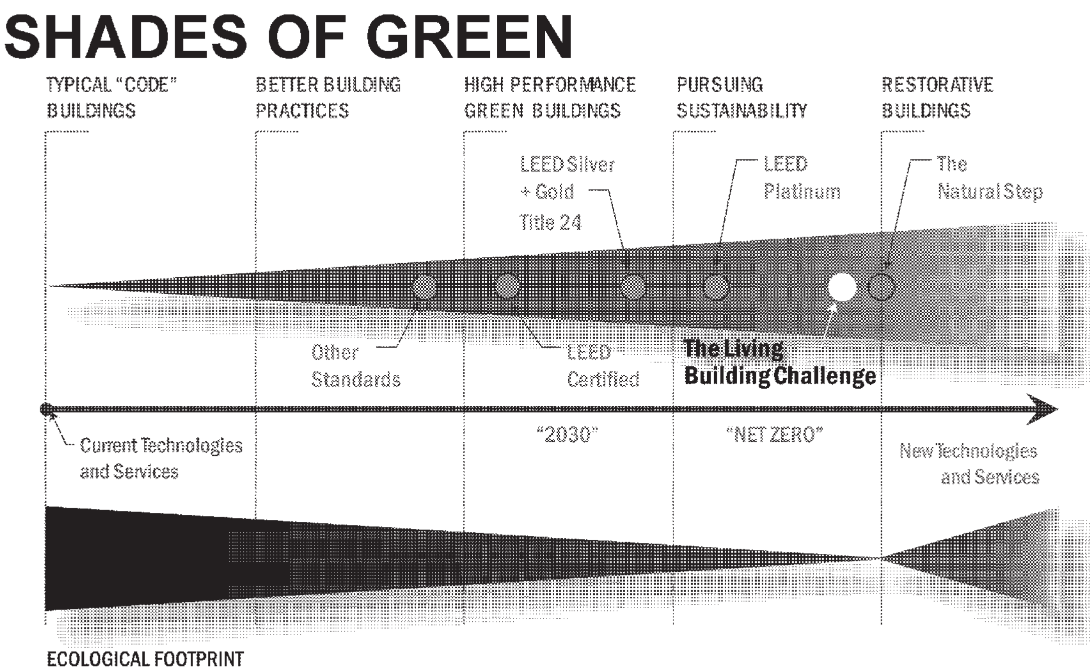
THE NEED TO KNOW

Getting to even this point has been a journey. In fact, it's been almost a decade in the making. The genesis for this study, in many ways, began with the David and Lucile Packard Foundation: Los Altos Project Sustainability Report (http://www.bnim.com/newsite/pdfs/2002-Report.pdf). The report, first completed in 2001 and updated in 2002, was the first comprehensive look at the costs of all levels of LEED construction, from entry-level certification through Platinum, and beyond.

Bookending this analysis was a benchmark market-rate, code compliant building and at the top end, a "Living Building." At that point in 2002, a Living Building was still just a conceptual framework, not part of any rating system.

Although the Packard matrix demonstrated that the level of Living Building was clearly the best long-term economic choice, the anticipated first cost premium was also quite significant for the proposed

FIGURE 2. Shades of Green. Illustrating where different building ratings sit on the scale of striving for a truly sustainable building.



foundation headquarters located in the San Francisco Bay Area of California. At that time, many of the requirements of the Living Building Challenge were not defined and, as a result, could not be clarified and priced.

Since 2002, there has been a remarkable uptick in the number of LEED projects in the marketplace. This shift, along with a general increase in the number of projects pursuing green building goals and using high performance sustainable systems and materials, has reduced the first cost premiums previously associated with the creation of a LEED building. The 2004 GSA LEED Cost Study prepared by Steven Winter Associates and Skanska, indicated that LEED Certified buildings could be achieved for no additional cost and LEED Silver buildings could be achieved for a cost premium of approximately 2.5%. In a July 2007 report "Cost of Green Revisited," construction consultants Davis Langdon found "there is no significant difference in average cost for green buildings as compared to non-green buildings." Cost data began to change the way people thought about building green.

During this same time, the costs associated with achieving a Living Building were not being reconsidered, since the last revision of the Packard study in 2002.

GENESIS OF THE LIVING BUILDING CHALLENGE

At the 2006 GreenBuild Expo, the Cascadia Green Building Council formally announced the release of the Living Building Challenge (http://www.ilbi.org/the-standard/version-1-3).

The idea for the Living Building, as noted above, wasn't new. In fact, the embryonic research that led to the Packard Study emerged much earlier in connection with the NIST-funded EpiCenter project in Bozeman, Montana in the mid-1990s, with the term and concept coined by Jason F. McLennan and Bob Berkebile of BNIM Architects.

From its early beginnings as a developing framework for what was to be the most advanced sustainable design project in the world, the ideas behind Living Buildings continued to grow and develop. In 2005, McLennan, the lead researcher for the EpiCenter project, turned the conceptual idea of a Living Building into a building rating system based around a set of sixteen simple, yet profound, prerequisites that became the Living Building Challenge version 1.0, which McLennan provided as a gift to Cascadia in August 2006.

In 2008 Cascadia released a Request for Proposals (RFP) for development of the Living Building Financial Study to continue to advance knowledge around the Challenge. They also released version 1.3, the most current version of the Challenge.

The Living Building Financial Study was completed in early 2009, and was designed to provide much needed, up-to-date information on the incremental cost between LEED Gold buildings and Living Buildings, and to answer the questions regarding the anticipated payback.

Because the costs of high performance buildings can vary significantly by building type and location, a range of building types in a variety of climate zones were studied. In fact, a huge motivator for this study was the desire to gain an understanding of how differences in climate, geography, size, and building typology affect cost.

Moreover, while interest in achievement of this level of sustainable design beyond LEED Platinum continues to grow, a true Living Building has yet to be certified. As of this writing, there are two buildings that have completed construction and are beginning their certification period. There are over 60 projects around the country that are registered with Cascadia and are seriously pursuing the Challenge.

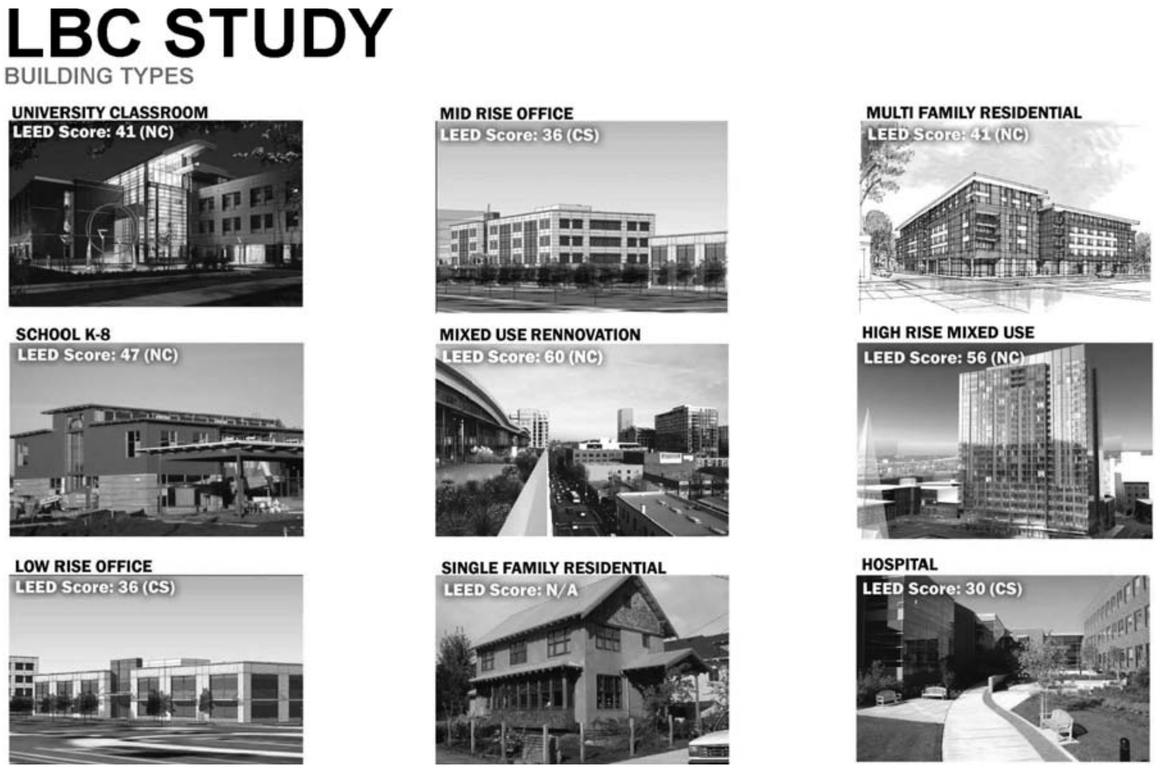
STUDY METHODOLOGY

In order to put a price tag on an idea, in this case the Living Building Challenge, the idea must be translated into a model, with form, place, and quality defined.

For the study, a team led by SERA Architects, joined by Skanska USA Building, Gerding/Edlen Development, New Buildings Institute, and Interface Engineering, and in partnership with the staff of Cascadia, conceptually transformed nine LEED Gold buildings into Living Buildings.

As wonderful as it would have been to have unlimited funds to build thirty-six actual Living Buildings (nine in each climate city) and report on actual costs, that obviously wasn't feasible.

FIGURE 3. Building Types. Building types were selected as the development models for the Living Building financial study to study a common platform in construction types representing a variety of development models.



Instead, the selected buildings were existing projects, each completed at least through construction documents. They were chosen to represent a variety of development models ranging from a single family residence developed by an individual owner to a publicly-developed university classroom building and a 17-story mixed use skyscraper developed by study team member Gerding Edlen, a Portland area green developer.

The buildings characterize a range of uses, each of which was evaluated in four climate cities: Portland (temperate), Atlanta (hot-humid), Phoenix (hot-arid) and Boston (cool), to determine the base building's energy and water usage.

The entire study team engaged in a dialogue to identify and sketch the characteristics of the projects to be studied in order that conceptual level cost estimates could be prepared. The project's base estimates were normalized to January 2009 dollars so baseline costs for each building in each climate city could be established.

A Living Building Prerequisite Cost Summary, which outlines the cost approach for each of the 16 prerequisites, is included in the body of the full report text. Several prerequisites do *not* add significant cost including Responsible Site Selection and Limits to Growth.

Other prerequisites such as the Materials Redlist and the Appropriate Materials/Service Radius are more difficult to quantify. Four prerequisites—Net Zero Energy, Net Zero Water, Sustainable Water Discharge, and Civilized Environment—were responsible for the greatest changes to each building's characteristics, and to some degree were the focus of the financial study's redesign efforts

A set of design modifications, energy conservation strategies, and rainwater collection techniques were proposed for each building to arrive at reduced

FIGURE 4. Climate Map. Four major cities were selected to represent the four major climate zones: Portland (temperate), Atlanta (hot-humid), Phoenix (hot-arid) and Boston (cool), to determine base construction cost and climate effects on green building.

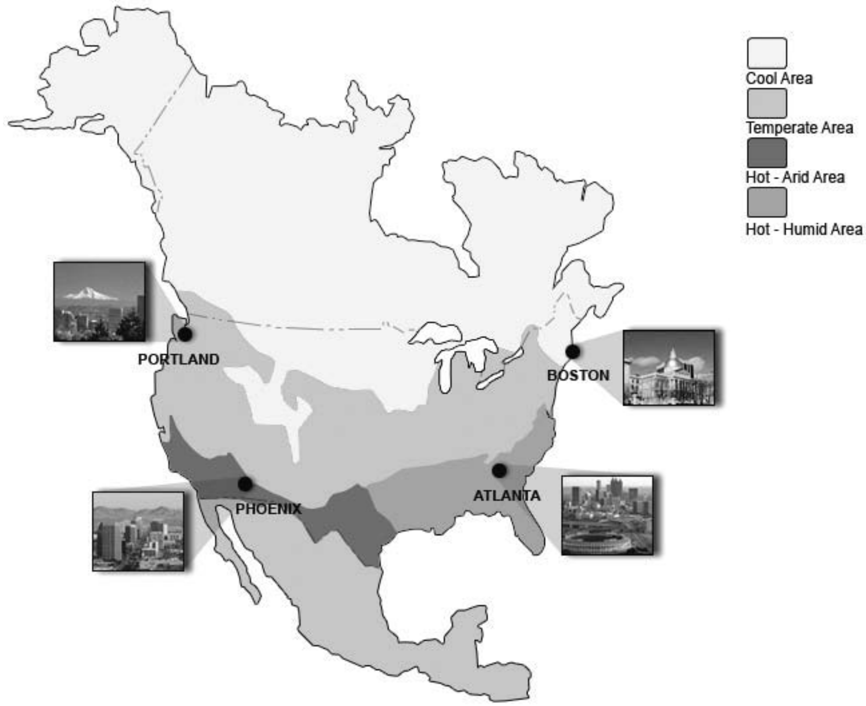


FIGURE 5. Construction Cost. The project's base estimates were normalized to January 2009 dollars so baseline costs for each building in each climate city could be established.

building water and energy usage before photovoltaics and water reuse strategies were applied. Simply put, our integrated project delivery team "ate its conservation vegetables before getting our solar cookies." The team endeavored to employ the least expensive strategies for all prerequisites, only utilizing expensive systems after energy consumption was maximally reduced and when the climate conditions dictated that they were required. After the most cost-effective energy conservation strategies were employed, photovoltaics were used in a standardized fashion as the energy source to close the gap to net zero. It was understood that specific projects in specific microclimates could use alternate sources for clean, renewable energy on-site, such as wind power.

The estimating team took a considered approach to anticipating the complete scope of each project, adding allowances for a full tenant build-out if it was not included in the base project. Living Buildings demand an integrated approach to design using highly skilled and experienced architects, engineers, and contractors; likewise, the estimate could not assume that features would be bolted-on in isolation of one another. The cost estimating team worked with the design team throughout the process to define and estimate the design intent.

The cost model reflects a best net-value interpretation of strategies and systems necessary to achieve the goals of the Living Building Challenge. Revisions required for the Challenge reflect regionally sensitive interpretations of the baseline building, including materials and systems appropriate to local building practices. Additionally, the estimates incorporate industry-recognized contingencies, regional cost data derived from Skanska's cost database, and soft costs adjusted to approximate the updated pricing.

PAYBACK

For the Living Building Financial Study, the team performed a simplified life cycle cost analysis. First the cost estimating team compared each LEED Gold building's baseline costs to the costs projected for its respective Living Building modification (adjusted to January 2009 dollars), to arrive at the net present value for each building.

Energy and water costs for the LEED Gold baseline buildings were calculated using a differential escalation rate of 3 percent for energy and water in accordance with the Federal Energy Management Program (FEMP). Current energy and water rates were multiplied by the present worth factor of 24.165. (This factor reflects a 30-year life-cycle, 4.5 percent discount rate, and 3 percent differential escalation.)

The total life cycle cost looks at both the annual cost and the present worth of the building to arrive at a present worth for the LEED Gold buildings. The Living Buildings do not have energy and water operational costs added to them as they will have net-zero energy and net-zero water usage. Other operations and maintenance costs were not included in the study due to constraints of time and research funds.

RESULTS

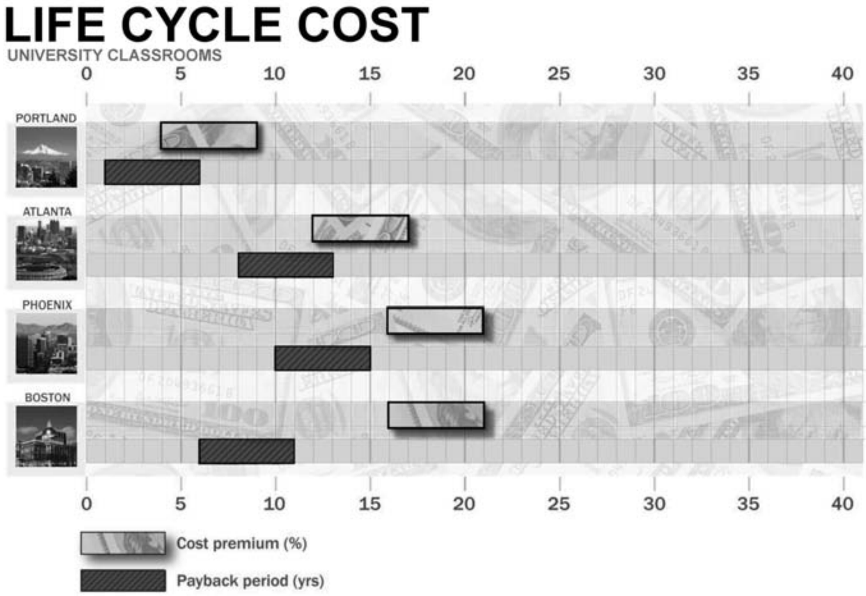
Conceptual estimating is part science and part art. We know the numbers derived in the study will not perfectly apply to every project, but the relative cost differences between building types, system types, and climate cities were carefully derived. The cost models endeavor to establish a cost increment for Living Buildings, recognizing that every project will vary from these results in response to its unique requirements, location, and market conditions. More important than the absolute numbers derived for the small sample of specific projects analyzed in this study are the general insights gained in what influences the costs of a Living Building and the range of potential costs and benefits that one might find. We believe that the results are exciting and encouraging for the rapid adoption of Living Buildings everywhere.

KEY FINDINGS

Despite prevailing perceptions about high first costs, we've reached a point where Living Buildings can be built cost effectively in today's market-driven economy if "cost effectiveness" takes into consideration the life-cycle impacts of the declining value of money and the rising costs of energy and water.

The first cost premiums for many building types are significantly lower than what many would predict for an energy and water independent structure. The degree of cost effectiveness depends on the interplay of four factors: client, climate, building scale, and building use. Also, the study found that two other factors—the availability of meaningful incentives and the regional costs of energy and water resources—can tip the scales for economic competitiveness.

FIGURE 6. Life Cycle Cost. A Life Cycle Analysis was done to determine the payback period on the construction of the building. This diagram represents the life cycle cost for the University classroom building type.



1. Client Type Matters

Whom the building is developed for and their goals and priorities greatly affect the initial budget for the base building, which in turn affects the first cost premium for Living Buildings.

Living Buildings are more likely to be built in market sectors where building owners and developers are long-term holders of real estate and therefore also consider operational costs, as opposed to those project types that are more first cost driven. Public buildings (which were represented in the study by university classroom facilities and elementary schools), are typically designed and constructed as 50- to 100-year buildings and therefore had the lowest cost premium, followed by buildings built by green developers for a specific market niche, followed by market driven developers, with speculative buildings showing the highest first cost premium.

2. Climate Matters

Climate exerts a significant influence on the first cost premium to create a Living Building.

Extremes in climate affect both the demand for energy and the availability of water in the form of rainfall. The milder a climate, the less energy expended to achieve human comfort. Not surprisingly, both the quantity of rainfall and its frequency throughout the year affect the cost premium to achieve net zero water.

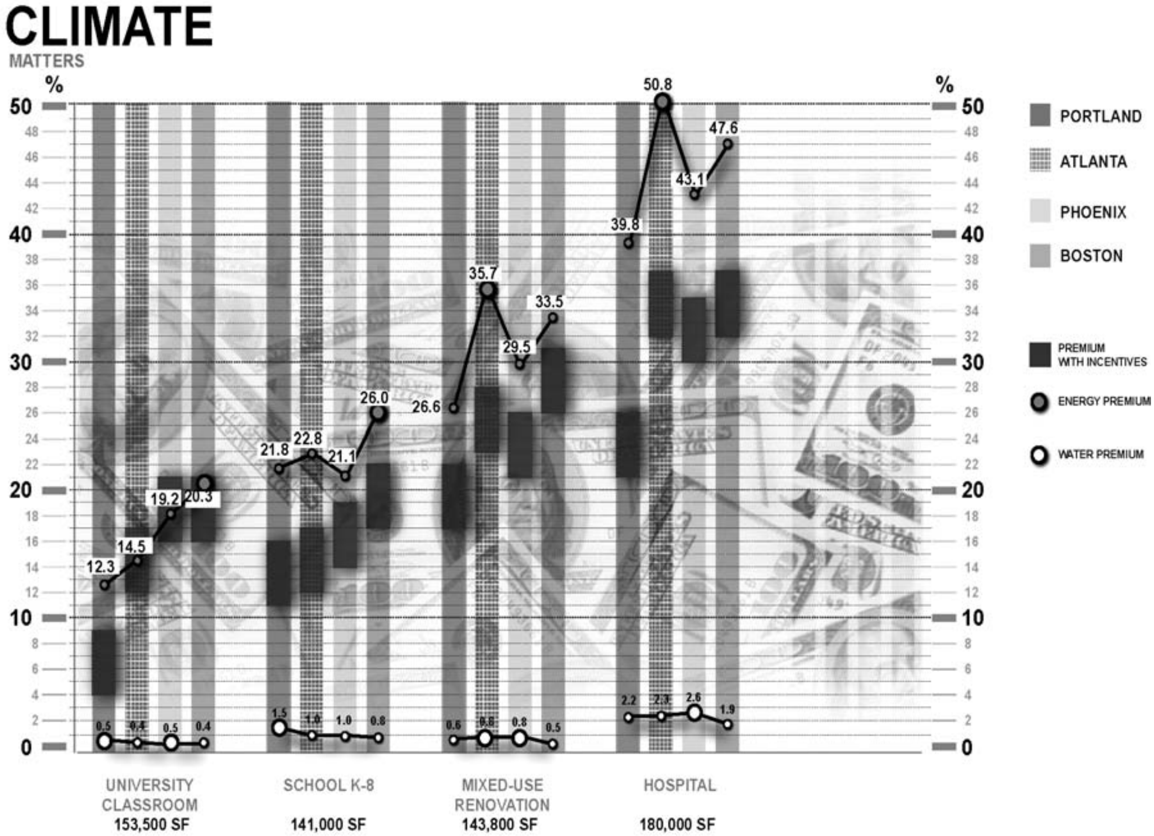
Both Atlanta and Phoenix generally showed lower energy use intensities and had the highest production per unit of area for photovoltaics. Even though Portland had slightly higher overall energy use intensities (EUI), its lack of extreme temperatures (for both heating and cooling) and relatively abundant rainfall translated into the elimination of systems for some building types, reducing the overall cost premium. On the other hand, Boston's more extreme temperatures led to increased energy use for the base building, both for heating and cooling, while Phoenix's low water availability led to higher water collection and treatment costs.

3. Scale Matters

The scale of the building, both in absolute size and the ratio of floor area to roof area, affects the cost premium to build a Living Building.

The absolute scale of the building affects the affordability of many of the systems necessary to achieve Living Building status. For very small

FIGURE 7. Climate Matters. This comparative analysis shows the cost effect of climate on building types of similar scale.



buildings, such as the single family residential building, the cost of adding the systems necessary to achieve Living Building status are great compared to first cost, driving up the cost premium. For larger buildings, the cost premium for Living Building features relative to the total project cost is much less, minimizing the cost premium.

The relationship of the building's floor area to its roof area also affects the affordability of achieving Living Building status, since roof area is the determinant for both the size of the photovoltaic array, which can be easily installed without building additional infrastructure, and for the amount of rainwater that can easily be collected.

To achieve net zero energy, buildings with a large floor area to roof area ratio (e.g., high rise buildings) needed to provide additional structure to support photovoltaics not integral to the building. As one might imagine, doing so adds to project costs. To achieve net zero water, the most economical buildings were those that could meet their water needs with rainfall alone since they did not need to provide additional treatment for grey and black water.

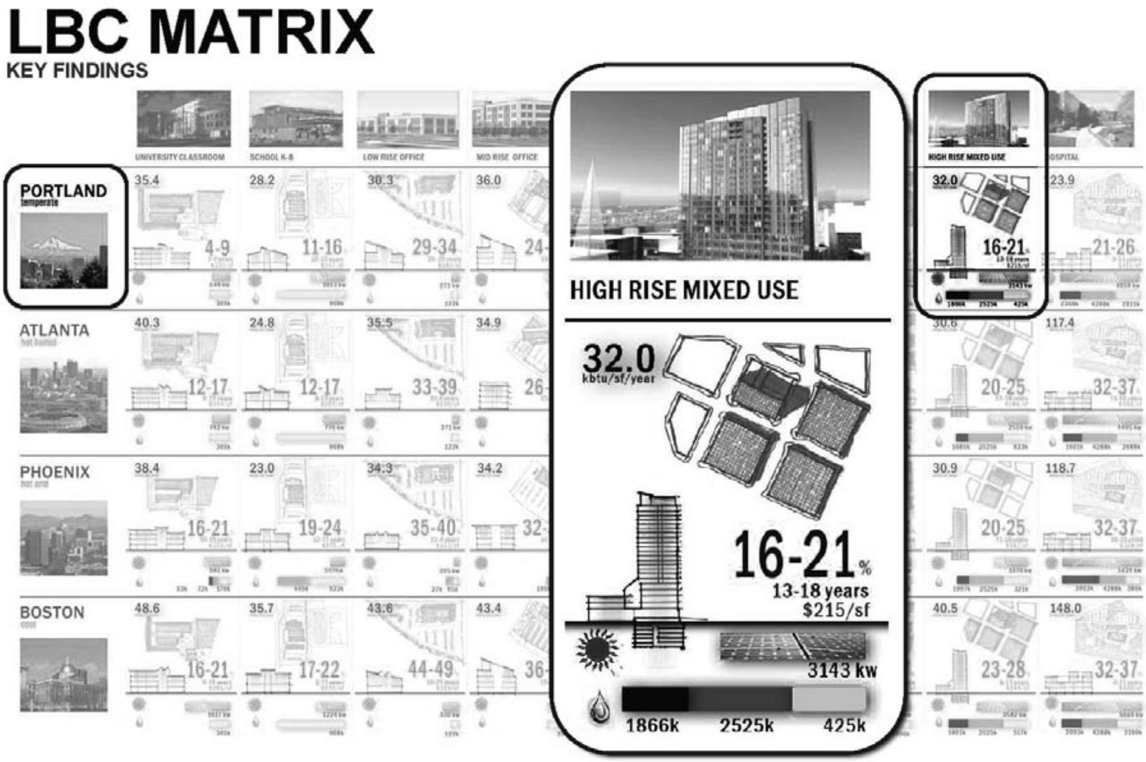
4. Building Use Matters

The primary and secondary uses of a building greatly affect its energy and water usage, which in turn affects the cost premium to build a Living Building.

A building's use determines the base energy and water consumption before conservation strategies are applied. The base building's energy use intensity and water usage affects the project's ability to achieve net zero energy and net zero water for a given floor to roof area ratio.

If buildings of the same size and height are considered, we see the impact of building use most

FIGURE 8. LBC matrix. This diagram shows a blow up of an individual cell of the matrix.



extensively. Residential buildings, such as a multifamily residential building, are constrained by the project's ability to collect rainfall for use far in advance of exceeding the project's ability to achieve net zero energy. The opposite is true for office buildings, where the energy produced by the project's photovoltaics governs.

5. Incentives Matter

The availability of incentives for green building projects can dramatically decrease the first cost of a project.

Living Buildings are more likely to be built first in market sectors where building owners and developers have robust incentives in place for the incorporation of green building practices. Portland is the second most expensive city in the study to build based solely on regional construction cost, remaining second after the Living Building features have been added. However, after available incentives have been subtracted, the cost premium goes down significantly, making Portland the least costly overall to build for all building types.

6. Cost of Energy and Water Matters

The cost of energy and water affects the payback.

The cost of energy is lowest in Portland and highest in Boston. Phoenix, ironically, has the lowest cost for water, with Boston again having the highest cost. Despite the large difference in cost premium for Boston and Portland, we see that the costs of water and energy affect the payback greatly and in normalizing the result.

Boston, the city with the highest energy and water costs, also had the highest regional construction cost premium, yet it had the fastest payback for eight of the nine buildings! Clearly energy price points can, and will, be effective in the built environment; as we have already seen they are in the world of petroleum.

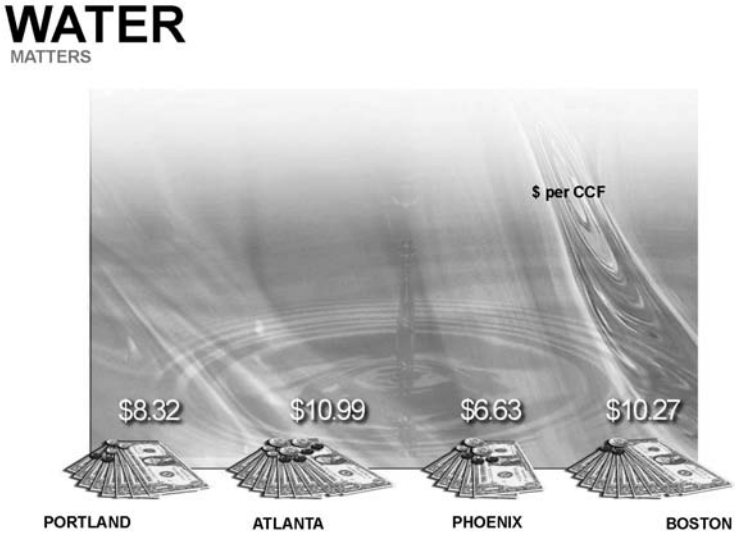


FIGURE 9. Water Cost. This diagram shows the relative costs of water between the four climate zones.

In summary, it is interesting to note that the best performing building in the study (both in terms of its 4%–9% first cost premium and its 2–7 year payback) was the University Classroom building designed for Portland. This building's size (~80,000 g.s.f.) combined with its relatively low profile (3–4 stories) matched up perfectly to optimize net zero energy and water systems. The University client type already consistently builds very green buildings designed to last for 60–100 years, so that also gave it a leg up. In addition, the Portland version of the building was able to capitalize on system reductions due to the mild climate and on additional monetary incentives that greatly improved the project's first cost. Clearly, all of the findings above have degrees of validity for all of the building types in all of the climate cities, but when design and construction teams can start to capitalize on multiple, synergistic benefits such as those put forth for the University Classroom building in Portland, the entire industry will experience significant shifts.

A LIVING BUILDING FUTURE

What the study shows is that Living Buildings can be achieved from coast to coast. While some markets and climates present specific challenges—not the least of which is payback time—it is clear that the industry can safely move Living Buildings from aspiration to actualization.

It's easy to anticipate owners who plan to own and operate a building for 50 to 100 years being the first to build Living Buildings. Over a longer lifecycle, initial costs of a Living Building will be recouped followed by ongoing operational savings.

It will be fascinating to observe corporate entities and residential developers take the steps to be pioneers in the creation of Living Buildings. While many activists will be excited about the social and cultural ramifications of net zero facilities, the long-term bottom line effects of Living Buildings will become more and more attractive to corporations and investors, especially as volatility in the energy and water markets increase.

While uncontrolled overhead costs—such as energy and water use—are becoming more of a burden on businesses, we cannot count on these pressures alone to drive the development of Living Buildings. There is too much variability in the various construction markets, climate impacts, and resource costs. Incentive programs will need to be established throughout the country to continue to accelerate market transformation. Taking the economic long view, in a world of finite resources, and growing external constraints such as climate change, a future with an emphasis on buildings that make all of the energy they use, consume only the water that falls on their site, manage all of their "waste," and do so with non-toxic materials seems more than likely. It's only a matter of time.

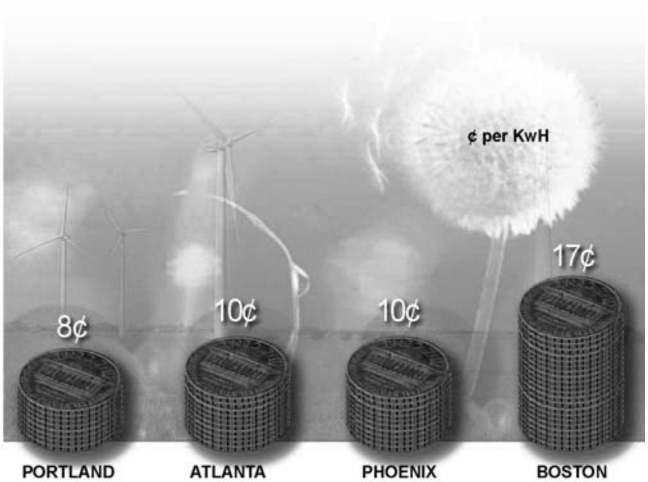


FIGURE 10. Energy Cost. This diagram shows the relative costs of energy between the four climate zones.

FIGURE 11. Matrix. For further information download the executive summary of the financial study. (http://ilbi.org/resources/research/financial-study/financial-study)