AN ANALYSIS OF MARKET, FINANCING, REGULATORY AND GEOGRAPHIC BARRIERS TO ZERO ENERGY BUILDINGS

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Mithun
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EXECUTIVE SUMMARY

In most European countries and parts of America, zero energy buildings have come to be seen as the next frontier or gold standard for new construction across all sectors of the building industry. This constant push for the highest level of sustainability in buildings, for the most part, comes as a result of the growing burden on worldwide energy demands and the increasingly unpredictable effects of climate change, which in turn makes zero energy buildings a very attractive solution to help mitigate the devastating impacts of global warming on our world.

In the United States, there are currently ten certified zero energy buildings in the U.S. Department of Energy (DOE) database, seven certified “Living” buildings and twelve projects who have entered the twelve-month operational phase required prior to audit under the Living Building Challenge project certification. On a federal level, the U.S. DOE developed the Net-Zero Energy Commercial Building Initiative (CBI) in 2007 with the goal of targeting net-zero energy status for 50% of U.S. commercial buildings by 2040 and net-zero energy for all U.S. commercial buildings by 2050. In Seattle, the first version of the Living Building Challenge (LBC) was designed in 2006 to provide “the most advanced measure of sustainability in the built environment possible today and acts to diminish the gap between current limits and ideal solutions.”

To understand the challenges facing zero energy developments, a questionnaire was sent to 21 professionals in the building industry. With this primary data, access to financials from built ZEB projects and the latest research sources, I analyzed these barriers through four categories: market, financing, regulatory and geographic. Below are the key findings of the research:

- The three strongest concerns about zero energy buildings are the lack of a standard valuation methodology, perceived financial risk and cost.
- Still challenging but to a lesser extent are the issues of on-site energy generation and the cost of utility loads for larger buildings.

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• Barriers that do not affect the development of zero energy buildings very much include exposure and presence in the marketplace, the willingness of the local community to embrace new construction methods and local climate.

Despite growing demand for these buildings, research findings indicate that there is still a large gap between financing structures and policies related to zero energy buildings that need to be resolved, perhaps with methods that are as ambitious and unconventional as these developments themselves. As cities begin to steadily incorporate these buildings as part of their larger sustainability initiatives, the demand for zero energy buildings that work on a multi-building or district scale will certainly increase in the interest of developing the most energy-efficient and cost-effective model of implementation.
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Introduction to Research Question and Relevance

The first commercial Zero Energy Building (ZEB)\(^4\) in the United States was a center for environmental studies in Ohio, the Adam Joseph Lewis Center at Oberlin College, completed in 2000.\(^5\) The project was largely conceived as an experiment in sustainable architecture. In July 2009, the Seattle-based architecture firm Mithun completed Lopez Common Ground, its first zero energy affordable housing neighborhood on Lopez Island in Washington State.\(^6\) Currently, there are only ten ZEBs in the U.S. Department of Energy Building Technologies Program database\(^7\). With ZEB’s small but emerging overall market presence in the United States, Mithun, my client and I are interested in researching the reasons as to why ZEBs are not yet the norm for new construction and the type of challenges that are discouraging this type of development.

Using Mithun’s home base of Seattle, Washington as a primary city for research, this paper aims to 1) analyze the different definitions, history and market prevalence of ZEBs 2) examine barriers that are currently preventing ZEBs from being established as the industry standard in Seattle, and how they affect choices in new construction and renovation.

Why study zero energy buildings, and in what ways is the topic relevant, if at all? On a personal level, it is a first-hand opportunity for me to satisfy my intellectual curiosity on a relatively new movement that is on the cusp of building momentum in the building industry. For Mithun, who originally suggested this research idea, a close analysis of the various factors that discourage zero energy developments could help in further understanding the barriers between costs and incentives when planning for future projects. On a larger scale, other cities could benefit from the lessons learnt from these early ZEB examples in Seattle in their quest to understand how to structure incentives in encouraging zero energy developments as part of their long-term sustainability goals. The outcome of this research paper would be: 1) An analysis of four identified barriers (market, financing, regulatory, geographic) that support or deter ZEBs

\(^4\) Also commonly interchanged with the terms Net Zero Energy, Zero Net Energy, Net-Zero Energy Building or Net Zero Building. Net Zero Water and Net Zero Waste are also approaches used in conjunction or separately from Net Zero Energy in buildings systems, but my research will focus exclusively on Net Zero Energy buildings because of the relatively substantial body of data available on the topic, ongoing large scale research initiatives and the number of successful examples of built prototypes in the United States.


2) Financing and policy recommendations for city-level decision makers, users and the private sector based on the analysis to help cities incorporate ZEBs more effectively as part of their future sustainability goals.

**Zero Energy Buildings: Definitions and Classifications**

In the last ten years, the concept of zero energy buildings has sparked great interest and emerged as the next frontier for new construction in the United States. What are zero energy buildings? In general, a zero energy building is a residential or commercial building with greatly reduced energy needs, where efficiency gains enable the balance of energy needs to be offset with renewable energy technologies, as illustrated by Figure 1 below:

![Zero Energy Building Concept](image)

**Figure 1. Zero Energy Building Concept**

To clarify ZEB definitions and to avoid misunderstanding among professionals in the building industry, the National Renewable Energy Laboratory (NREL), a national laboratory of the U.S. Department of Energy under the Office of Energy Efficiency and Renewable Energy, has published two reference documents: *Zero Energy Buildings: A Critical Look at the Definition*[^9], which describes four main NZEB definitions and *Getting to Net Zero*[^10], which classifies ZEBs based on the renewable energy sources used in the building. There are two conditions for a building to be classified as a ZEB: 1) It must reduce site energy through energy efficiency and demand-side renewable energy technologies and 2) It must use supple-side renewable energy according to one of the four ZEB classifications shown in Table 1 on page 4.

Some examples of demand-side renewable energy technologies could include but are not limited to passive solar heating, daylighting, high-efficiency HVAC equipment, evaporative cooling, ground-source heat pumps and evaporative cooling. According to *Zero Energy Buildings: A Critical Look at the Definition*, the four main ZEB definitions are:

1. **Net Zero Site Energy**: A site ZEB produces (and exports) at least as much renewable energy as it uses in a year, when accounted for at the site.

2. **Net Zero Source Energy**: A source ZEB produces and exports (or purchases) at least as much renewable energy as it uses in a year, when accounted for at the source. Source energy refers to the primary energy used to extract, process, generate, and deliver the energy to the site. To calculate a building’s total source energy, imported and exported energy is multiplied by the appropriate site-to-source conversion multipliers based on the utility’s source energy type.

3. **Net Zero Energy Costs**: In a cost ZEB, the amount of money the utility pays the building owner for the renewable energy the building exports to the grid is at least equal to the amount the owner pays the utility for the energy services and energy used over the year.

4. **Net Zero Emissions**: A net zero emissions building produces (or purchases) enough emissions-free renewable energy to offset emissions from all energy used in the building annually. Carbon, nitrogen oxides, and sulfur oxides are common emissions that NZEBs offset. To calculate a building’s total emissions, imported and exported energy is multiplied by the appropriate emission multipliers based on the utility’s emissions and on-site generation emissions (if there are any).

In *Getting to Net Zero*, ZEBs are further categorized by their respective renewable energy supply:

<table>
<thead>
<tr>
<th>ZEB Classification</th>
<th>ZEB Supply-Side Options</th>
<th>ZEB Definitions</th>
</tr>
</thead>
<tbody>
<tr>
<td>On-Site Supply Options</td>
<td>Use renewable energy sources available within the building’s footprint and dedicated to the building. (Examples: Photovoltaic, solar hot water, and wind located on the building.)</td>
<td>YES: Site, Source, Emissions Difficult: Cost</td>
</tr>
</tbody>
</table>
For the purposes of this research, the Net Zero Site Energy definition will be used as it is the most common form found in successful built examples. How does one select a ZEB definition and classification to apply when faced with so many choices? NREL suggests that each building’s approach should be selected in accordance with its owner’s goals as each method has

<table>
<thead>
<tr>
<th></th>
<th>Use renewable energy sources as described in ZEB:A And/or Use renewable energy sources available at the building site and dedicated to the building. (Examples: Photovoltaic, solar hot water, low-impact hydroelectric, and wind located on parking lots, adjacent open space, but not physically mounted on the building)</th>
<th>YES: Site, Source, Cost, Emissions Difficult: Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Off-Site Supply Options</td>
<td>Use renewable energy sources as described in ZEB:Aand/or ZEB:B And Use renewable energy sources available off site to generate energy on site and dedicated to the building. (Examples: Biomass, wood pellets, ethanol, or biodiesel that can be imported from off site, or collected from waste streams from on-site processes that can be used on site to generate electricity and heat.)</td>
<td>YES: Site, Difficult: Source, Cost, Emissions</td>
</tr>
<tr>
<td>C</td>
<td>Use renewable energy sources as described in ZEB:A, ZEB:B, and /or ZEB:C And Purchase recently added off-site renewable energy sources, as certified from Green-E (2009) or other equivalent renewable energy certification programs. Continue to purchase the generation from this new resource to maintain ZEB status. (Examples: Utility-based wind, photovoltaic, emissions credits, or other “green” purchasing options. All off-site purchases must be certified as recently added renewable energy (Green-E 2009). A building could also negotiate with its power provider to install dedicated wind turbines or PV panels at a site with good solar or wind resources off-site. In this approach, the building might own the hardware and receive credits for the power. The power company or a contractor would maintain the hardware.)</td>
<td>YES: Source, Emissions NO: Site, Cost</td>
</tr>
</tbody>
</table>

Table 1. Classifying NZEBs by Renewable Energy Supply
its pros and cons and that there is no “best” definition or way to account for energy use\textsuperscript{11}. One critical rule should be considered first and foremost in designing buildings for selected ZEB definitions and classifications, however; tackle energy \textit{demand} first, and then \textit{supply}.

\textbf{Zero Energy Buildings and Sustainability}

In examining how zero energy buildings relate to sustainability as a whole, we must first understand the reasons behind the need for more energy-efficient buildings in our world. It comes as no surprise that the energy use of buildings have a significant impact on the environment. Data from the 2012 U.S. Energy Information Administration Annual Review indicate that commercial and residential buildings used a total of 39.4\% of the total fossil fuel energy in the United States and European Union, roughly a 7\% increase from three decades ago, and approximately 70\% of the electricity consumption in the United States.\textsuperscript{12}

Electricity consumption in the commercial building sector doubled between 1980 and 2000, and is expected to increase another 50\% by 2025, primarily because new buildings are constructed faster than old ones are demolished or retired.\textsuperscript{13} Until buildings are designed to produce more energy than they use to offset the growing burden on worldwide energy demands, energy consumption in the commercial building sector will continue to increase to levels that are ultimately unsustainable; further compounding the unpredictable and devastating impacts of global warming.

Given the pressing demands of climate change, it is imperative that we need to find a capacity to endure, steward available resources and develop in a way that “meets the needs of the present without compromising the ability of future generations to meet their own needs”\textsuperscript{14}—in short, the most widely-quoted definition of sustainability as determined by the Brundtland

\textsuperscript{13} Ibid.
Commission\textsuperscript{15} convened by the United Nations in 1987. This definition also emphasizes how social and economic goals should be defined in terms of sustainability with the consideration of the environment’s ability to meet present and future needs---a concept which was further developed into the “triple bottom line” approach\textsuperscript{16}. The triple bottom line approach thus consists of three Ps: people, planet and profit and aims to fully measure and account for the social, environmental and financial performance of an entity or organization over a period of time.

Through the triple bottom line approach, zero energy buildings represent a great opportunity to help advance sustainability goals and mitigate the impacts of global warming. Because ZEBs allow for a wide range of approaches due to the many options for producing, conserving and measuring energy, they bring economic benefits by reducing demands on energy production, keeping energy prices and building operational expenses low. As ZEBs utilize renewable energy sources exclusively, carbon emissions and fossil fuel dependency are reduced to a minimum, keeping the environment clean and free from pollutants. Last but not least, users and occupants benefit from increased indoor air quality and thermal comfort due to more-uniform interior temperatures in ZEB buildings, thereby increasing their health and quality of life as a whole.

\textit{Market Sizes of Zero Energy Buildings: A Global and Local Comparison}

On a global scale, the International Energy Agency\textsuperscript{17} has been engaged in an ongoing collaborative five-year process of collecting data on built ZEB and energy-plus\textsuperscript{18} buildings around the world since September 2008. So far, approximately 300 buildings from 19 countries have been documented, giving an idea of the gradual spread and uptake of ZEBs in the industry. While the overall market growth remains slow for the next 10 years, the ZEB industry is poised

\textsuperscript{15} A commission established by the United Nations in December 1983 to rally countries to work and pursue sustainable development together. The Brundtland Commission was officially dissolved in December 1987 after releasing the \textit{Brundtland Report}, also known as \textit{Our Common Future}, in October 1987. The organization Center for Our Common Future was started in April 1988 to take place of the commission.

\textsuperscript{16} A term first coined in 1994 by John Elkington, the founder of a British consultancy named \textit{Sustainability}.

\textsuperscript{17} The International Energy Agency (IEA) was established in 1974 as an autonomous agency within the framework of the Economic Cooperation and Development (OECD) to carry out a comprehensive program of energy cooperation among its 25 member countries and the Commission of the European Communities. Member countries include: Australia, Austria, Belgium, Canada, China, Denmark, Finland, France, Germany, Italy, Mexico, Netherlands, Norway, Portugal, Singapore, South Africa, Spain, Sweden, Switzerland and the United States.

\textsuperscript{18} Energy-plus buildings produce more energy from renewable energy sources over the course of a year than it imports from external sources.
to undergo significant growth in year 2020, when the European Union will mandate zero energy building codes in public buildings by 2018 and in all new construction by 2020\textsuperscript{19}. Similar regulations are being discussed in Japan. The global market for ZEB technologies, which hovers at $225 million currently, is expected to grow to $1.3 trillion dollars by 2035, with European markets accounting for 90\% of that amount\textsuperscript{20}, as demonstrated in Figure 1 below:

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{zero_energy_building_revenue_by_region.png}
\caption{Zero Energy Building Revenue by Region, World Markets: 2011-2035\textsuperscript{21}}
\end{figure}

In the United States, there are currently ten zero energy buildings in the U.S. Department of Energy (DOE) Building Technologies database, seven certified “Living” buildings and twelve projects who have entered the twelve-month operational phase required prior to audit under the Living Building Challenge project certification.\textsuperscript{22} On a federal level, the U.S. DOE was authorized by Congress in the Energy Independence and Security Act of 2007 to develop the Net-Zero Energy Commercial Building Initiative (CBI) to support the goal of net-zero energy for all new commercial buildings by 2025. The initiative targets net-zero energy status for 50\% of


\textsuperscript{21} Ibid.

U.S. commercial buildings by 2040 and net-zero energy for all U.S. commercial buildings by 2050.\textsuperscript{23}

At present, the U.S. DOE is also working with public and private partners in leading the largest-scale zero energy building research in the United States. Its residential program, Building America, has set a goal of achieving marketable zero energy homes by 2020. Since August 2008, over $40 million has been awarded to four Building America teams. In addition, on October 5, 2009, President Barack Obama signed Executive Order 13514, a mandate that requires that “all new federal buildings must be designed to achieve “zero net energy” by FY 2030, starting in FY 2020.”\textsuperscript{24}

Within the building design professional societies, momentum is also building rapidly to meet the vision and challenge of ZEBs. Among the organizations that have established relevant strategic plans and programs are:

1) The United States Green Building Council (USGBC): In November 2006, the Cascadia Green Building Council\textsuperscript{25} launched the first version of the Living Building Challenge (LBC) to the public, a green building certification program that “defines the most advanced measure of sustainability in the built environment possible today and acts to diminish the gap between current limits and ideal solutions.”\textsuperscript{26} The Living Building Challenge is currently administered by the International Living Futures Institute and in its second version. The standard is comprised of seven “Petals” or performance areas, namely: Site, Water, Energy, Health, Materials, Equity and Beauty; under which net zero energy is one of the twenty “imperatives” or prerequisites to fulfill. Along with that, USGBC is in the process of developing a fourth version of its well-known LEED\textsuperscript{27} program in

\textsuperscript{25} The Cascadia Green Building Council is a chapter member of the USGBC and Canadian Green Building Council with a network of fourteen branches in Washington State, Oregon, Alaska and British Columbia.
\textsuperscript{27} LEED, also known as Leadership in Energy and Environmental Design, is a voluntary, consensus-based, market-driven program that provides third-party verification of green buildings. At the time of writing, LEED projects have been successfully established in 135 countries.
which net zero and net positive buildings will be criteria included in the scoring system.

2) **Architecture 2030 Challenge**: Started in 2002 as a stand-alone commitment for building sector participants, the Architecture 2030 Challenge sets forth a goal for reducing fossil fuel consumption to zero (carbon neutral) by year 2030, starting from a 60 percent reduction in 2010, with 10 percent additional reductions every 5 years. Organizations such as the U.S. Conference of Mayors, U.S. Green Building Council and ASHRAE have incorporated these goals as part of their sustainability action plan. The American Institute of Architects (AIA) has also used these targets as the framework for the AIA 2030 Commitment. Across the United States, 2030 Districts have been formed in four cities, Seattle, Cleveland, Pittsburgh and Los Angeles to meet performance goals called for by the 2030 Challenge through unique public-private partnership and grassroots efforts.

3) **ASHRAE**: In January 2008, the organization convened a committee to develop ASHRAE Vision 2020, an action plan focused on developing the “the tools necessary to design, construct, and operate ZEB’s” so that they are market-viable by 2030. ASHRAE aims to have the necessary tools in place by 2020 and has already completed its Advanced Energy Guides for small office buildings, small retail buildings, K-12 schools, and small warehouses. The development of user-friendly energy modeling interfaces, target energy budgets for building types and climates and equipment with greatly reduced plug loads are also in progress.

The small handful of early ZEB examples in the United States indicate that zero net energy is possible to achieve technically. However, the effective implementation of a cost-effective, large-scale ZEB model that can be replicated remains a challenge to be overcome.

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28 Architecture 2030 is a non-profit, non-partisan and independent organization established in response to the climate change crisis by architect Edward Mazria in 2002. Its mission is to rapidly transform the U.S. and global building sector from the major contributor of greenhouse gas emissions to a central part of the solution to the climate change, energy consumption, and economic crises.

29 ASHRAE, also known as the American Society of Heating, Refrigerating and Air-Conditioning Engineers, was founded in 1894. It is a building technology society with more than 54,000 members worldwide, focusing on building systems, energy efficiency, indoor air quality, refrigeration and sustainability within the industry.

Mithun and Zero Energy Buildings

My client and partner for this research project, Mithun, is an architecture firm with offices based in Seattle, Washington (headquarters) and San Francisco, California. Established in 1949, Mithun’s aims to “inspire a sustainable world through leadership, innovation and integrated design” and is renowned as a national leader in sustainable design and urbanism. The topic of zero energy buildings is relevant to Mithun for four main reasons.

Firstly, the firm has an integrated structure composed of architects, interior designers, landscape architects, urban designers and planners. With such a diverse set of professionals working on a project, a thorough knowledge of ZEB best practices in every department would help streamline communications and improve operations across the firm. Secondly, Mithun seeks to understand global issues and help to drive the best return on investments — economically, socially, environmentally and artistically. The concept of ZEBs and the benefits they bring about falls very much in line with the firm’s triple bottom line approach to work.

Thirdly, Mithun prides itself on building the “knowledge” database, a prominent feature on its website comprising of white papers, presentations, case studies, and speaking events that reveal the inspiration, research and theory behind the firm’s work. Being a topic that is relatively new to the building industry, ZEBs would be a natural topic of interest to Mithun and an opportunity to further its leadership role as active contributors to the International Living Futures Institute and the field of sustainability. Last but not least, a more in-depth study of ZEBs would add value to the firm in the evaluation of previous zero energy projects such as the affordable housing development on Lopez Island, Washington and the implementation of current and future developments such as the Ohio State University Net Zero Sustainability Plan.

Research Methodology and Timeline

With the relevance of zero energy buildings to Mithun’s goals firmly established, I developed a methodology to structure my approach in testing my hypothesis, namely, zero energy buildings are facing challenges discouraging them from being established as the standard in new construction. The methodology involves:

• Selecting a city to base my research on
• Setting a timeline for the project
• Selecting and making a list of subject informants to approach
• Developing and refining a framework and questionnaire for said informants to respond to
• Analyzing, compiling and comparing responses provided by the informants in accordance with secondary research sources

The research city of my choice is Seattle, Washington and the timeline for this project is one semester, or four and a half months. The initial scope of my project included the city of Austin, Texas as a point of comparison to Seattle. Austin would have been an interesting study for these reasons: its status as pioneering and forward-thinking Southern city similar in spirit to Seattle, the prevalent culture of sustainability and environmental-consciousness in local lifestyles and the building industry, the Austin Energy Green Building code that require all homes to be “net-zero-energy capable or able to operate completely off the grid by 2015”\(^{33}\) and last but not least, its year-round sunny climate.

However, after considering the scale and length of the paper, brief timeline and the inability to get responses from subject informants in Austin in a timely manner, I decided to narrow the scope down to Seattle. I wanted Seattle to be the main focus of my research for the following reasons: Mithun is headquartered there and its knowledge base and project profiles are heavily concentrated in the city, its existing dense urban conditions, its well-known overcast climate, the Seattle 2030 District and most importantly, the engaged and innovative community of professionals involved in the green building industry and trade organizations. Seattle’s existing conditions, so encouraging yet conflicting at the same time, would make for a fascinating, worthy and in-depth analysis.

Figure 2 on the next page illustrates the various phases in the timeline for this project. The subject informants were selected by Mithun based on the strength of their relationships, expertise in subject area, level of engagement in the local green building industry and network of relevant professionals.

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contacts. Twenty-one subjects were identified into three categories—municipal, designers and developers—all of whom I first approached and sent my questionnaire to via email.

Of the twenty-one, six subjects responded to my questionnaire, two of which I followed-up with subsequent phone conversations clarifying material in the questionnaire. Of the six who responded, two were developers, three were designers and one was from the municipal sector. In all, I received a 28.5% response rate yield in which I had primary sources from experts in the field to base my research on.

Figure 2. Research phases and timeline
Seattle: Setting the Stage for Zero Energy Buildings

The movement of the green building industry towards ZEBs in Seattle can be analyzed through three viewpoints— the private sector, the public sector and from a public-private partnership perspective. From a private sector perspective, the U.S. Green Building Council (USGBC) was established in 1993. In 1998, the first version of LEED was introduced to the public. A year later, the Cascadia Green Building Council was founded with the mission of “setting the global vision for the transformation toward true sustainability.” One of the earliest adopters of the green building movement, the organization has been actively promoting LEED since its founding in 1999. As of mid-2012, Washington State has 31 LEED Platinum-certified buildings. In 2006, the first version of the Living Building Challenge (LBC) was designed as an effort to produce a more advanced green building performance standard than LEED. The second and current version of the LBC was subsequently developed in 2009. In response to an increase in global attention and interest, the Cascadia Green Building Council founded the International Living Building Institute (now the International Living Future Institute) in 2009 as an umbrella organization to support and administer the LBC, which currently has seven certified Living Buildings and twelve more that are in the process of being approved.

From a public sector perspective, the City of Seattle Comprehensive Plan, last amended in 2004 and currently undergoing a major review, states the city’s intent to reduce carbon dioxide

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and greenhouse gas emissions from 1990 levels by 30 percent by 2024, and by 80 percent from 1990 levels by 2050\textsuperscript{36}. In 2008, the Washington State Legislature passed the EESB 6001, an act that establishes a goal for the State of Washington to reduce its output of greenhouse gas emissions to 1990 levels by 2020.\textsuperscript{37} As a commitment to these performance goals and to learning from the pioneering Living Building Challenge projects, the city of Seattle passed an ordinance establishing the Living Building Challenge Pilot Program in 2009. The goal of the Pilot Program, placed in effect in 2010, is to encourage the development of buildings that meet the Living Building Challenge by allowing departures from code requirements that might otherwise prevent buildings from meeting this standard\textsuperscript{38}. In addition, the program was intended to stimulate and encourage innovative developments that will serve as a model for other projects and identify barriers to Living Buildings in current codes and processes. Under the authority of the City of Seattle Department of Planning and Development, the first twelve developers complying with at least 60 percent of the Living Building Challenge requirements will be given flexibility and special incentives in terms of development standard departures. The program will be evaluated within five years after the effective date of the ordinance.

From a public-private partnership viewpoint, the Seattle 2030 District was started in 2010 with the goal of creating a groundbreaking high-performance district in downtown Seattle. The interdisciplinary collaborative is composed of property owners and managers, professional and community stakeholders, with the City of Seattle being an active member as well. The group aims to achieve targets at a district scale, focusing on existing privately-owned medium to large buildings, using the Architecture 2030 Challenge performance goals as a guide (see Figure 5 next page). Ultimately, the 2030 District aims to be seen as a strategic undertaking to help the City of Seattle meet its goal of carbon neutrality by 2030 and a working model that other cities and regions can use to reduce emissions and impacts, a major investment in Seattle’s future.


Case Studies: An Overview of Two Zero Energy Buildings in Seattle

1. Bertschi Living Building Science Wing39, Seattle, WA, USA

PROJECT DESCRIPTION

Bertschi School Living Science Building, located in Seattle’s Capitol Hill Neighborhood, was one of the first projects in the world to pursue the Living Building Challenge v2.0 criteria

and the first to achieve it. This non-profit elementary school science wing was collaboratively designed with the students and designed pro-bono by the entire design team. A 20-kilowatt PV system produces all of the electricity for the building and allows students to participate in real-time monitoring of the building’s energy use and solar power production. All the water needed for the building is collected and treated on site. This is done through a variety of methods including cisterns for storage, an interior green wall of tropical plants which treats greywater and a composting toilet to treat blackwater. The most important aspect of the project is that all sustainable features are visible and functional to students to learn ecological concepts that can become intrinsic values for future generations.

![Project Image]

**PROJECT VITAL STATS**

<table>
<thead>
<tr>
<th>Status</th>
<th>Certified “Living”</th>
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</thead>
<tbody>
<tr>
<td>Date Certified</td>
<td>April 10, 2013</td>
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<tr>
<td>Version of Program</td>
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<tr>
<td>Location</td>
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<td>Building Typeology</td>
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<tr>
<td>Number of Visitors</td>
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<td>Typical Hours of Operation</td>
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**PROJECT TEAM**

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<tr>
<td>Plumbing</td>
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<td>Mechanical</td>
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<tr>
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<td>OBrien &amp; Company</td>
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<tr>
<td>Contractor</td>
<td>Skanska USA Building, Inc.</td>
</tr>
<tr>
<td>Urban Ecologist</td>
<td>Back to Nature Design, LLC</td>
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<tr>
<td>Building Envelope Engineer</td>
<td>Medgar Marceau</td>
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COST AND FINANCING

<table>
<thead>
<tr>
<th>Soft Costs</th>
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<tbody>
<tr>
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</tr>
<tr>
<td>Total Project Cost</td>
<td>$ 935,000</td>
</tr>
<tr>
<td>Cost per square foot</td>
<td>$ 276</td>
</tr>
</tbody>
</table>

DESIGN PROCESS

The project began as an idea in the minds of Chris Hellstern and Stacy Smedley of KMD Architects. They happened on the Bertschi school by chance when looking to tour a local LEED Gold school. At the end of the tour, Bertschi’s campus planner Stan Richardson, mentioned that they wanted to explore the Living Building Challenge on the school. Chris and Stacy quickly reached out to build a team who shared their passion for sustainability. Each contact immediately said ‘yes’ to signing on to the pro-bono project. With the dedicated team in place, they approached the Bertschi School, who agreed to take on the Challenge.

2. Bullitt Center, Seattle, WA

PROJECT DESCRIPTION

The Bullitt Center aims to be the greenest commercial building in the world. The six-story, 50,000 square-foot building is located at the intersection of Capitol Hill and the Central District in Seattle, Washington. The goal of the Bullitt Center is to change the way buildings are designed, built and operated to improve long-term environmental performance and promote broader implementation of energy efficiency, renewable energy and other green building technologies in the Northwest. The building is seeking to meet the ambitious goals of the Living Building Challenge and was designed with the health of Puget Sound in mind, including efforts to educate people about site sustainability and non-point source pollution. Rainwater will be retained on site and “grey water” from sinks in the building will be filtered through a green roof. In addition, extensive use of pervious pavement that allows water to infiltrate into the soil below.

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40 All information in the Bullitt Center Case Study except cost is taken from the Bullitt Center’s official website. "Bullitt Center.” Bullitt Center. Accessed April 26, 2013. http://bullittcenter.org/building
will further reduce the impact of runoff on Puget Sound. Where possible, landscaping will act as a demonstration of the possibilities for green stormwater infrastructure and natural drainage systems. Low to medium height sidewalk plantings will establish a physical separation between the pedestrian and vehicle zones, without restricting views to and from these zones. These features are consistent with new development along Madison and will improve the pedestrian experience along this major thoroughfare.
COST AND FINANCING

<table>
<thead>
<tr>
<th>Sources</th>
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<tr>
<td>Bullitt Foundation</td>
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<td>US Treasury “1603” Grants</td>
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<td><strong>TOTAL SOURCES</strong></td>
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<table>
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<th>Uses</th>
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<td>Financing Costs</td>
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<tr>
<td><strong>TOTAL USES</strong></td>
<td><strong>$30,000,000</strong></td>
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Possible Challenges Facing Zero Energy Buildings

In analyzing local conditions that support or discourage ZEBs from being established as the norm in new construction in Seattle, four main barriers were identified, namely: market, financing, regulatory and geographic barriers. Each main barrier was subsequently broken down into smaller subtopics framed as questions for further analysis.

I. MARKET BARRIERS

*Is technology (or the lack of it) a barrier to ZEBs?*

Only renewable energy sources such as sun, wind and water can meet the requirements for ZEBs. Hence, the easiest means for buildings to generate their own energy is through solar photovoltaics (PV) on rooftops. However, energy generation through PV becomes a barrier if the building is over four stories tall or is a highly energy-intensive building such as a data center, laboratory or a hospital. If we assume that a building only has its roof area available for mounting PV, then a single-story building is much more likely to achieve net zero than a high-

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41 Cost information taken from the source below.

rise. A 2007 report from NREL confirms that getting to net zero energy is extremely difficult for buildings of more than four stories, as the floor area that could achieve net zero effectively as a function of number of floors is less than 3 percent\textsuperscript{42}, as shown in Figure 6 below. Hence, other energy sources are needed for high-rise buildings in an urban context that are not able to utilize PV effectively. Nearly all other sources of energy require some form of combustion, thus requiring an external fuel source. These advanced systems require a dedicated and sophisticated maintenance team, adding the extra complexity of having an organizational infrastructure to support the physical infrastructure as well.

\begin{figure}[h]
\centering
\includegraphics[width=0.5\textwidth]{limits_to_net_zero.png}
\caption{Limits to Net Zero for Multi-Story Buildings\textsuperscript{43}}
\end{figure}

Though solar technology is widely available in Seattle, the modest renewable energy production incentives\textsuperscript{44} and the lack of a state tax credit system for solar PV make the upfront costs difficult to justify on a pro forma. In the case of external fuel sources, the perception that unconventional energy-generating systems are unproven and prohibitively expensive makes it

\begin{footnotesize}
\begin{itemize}
\item \textsuperscript{43} Ibid.
\item \textsuperscript{44} The Washington State Renewable Energy Production Incentives offers a base-level production incentive of 15 cents per kilowatt-hour ($0.15/kWh) capped at $5,000 per year, for individuals, businesses, or local governments that generate electricity from solar power, wind power or anaerobic digesters. Higher incentive levels are available (up to 54 cents per kilowatt-hour) if the solar electric (PV) modules panels and/or inverter are manufactured in the State of Washington.
\end{itemize}
\end{footnotesize}
difficult to convince builders of the cost-effectiveness of ZEBs. The fact that the average energy rates in Seattle is the lowest in the United States (6.72 cents per kWh)\textsuperscript{45} as of 2011 further compounds this perception and drives users to fall back on conventional lighting and mechanical solutions. For larger buildings (more than 10,000 square feet), however, the cost of utility load becomes a deterrent as they represent a relatively large power plant connected to the power grid, despite the relatively cheap cost of electricity in Seattle. The utility provider must be able and willing to take that power into the grid at the location of the building, which may be a considerable distance away from the nearest substation, presenting an extra challenge to ZEBs. It is important to note that in both cases, it is not the lack of options available in the marketplace or the inability to install and operate these systems, rather, the cost of these technologies that remain a barrier to ZEBs.

\textbf{Are ZEBs facing a lack of exposure and presence in the market?}

Most of the early zero energy projects in the Pacific Northwest came about in the late 2000s, given that the momentum for ZEBs only came about after the Living Building Challenge standard was introduced in 2006 and the federal mandate for ZEBs was signed in 2007. As these early zero energy examples were either homes or small commercial buildings (less than 10,000 square feet), they were mostly located outside urban areas and major cities, resulting in them being relatively unknown to the general public. However, one particular ZEB, the Bullitt Center in Seattle, has been extremely successful attracting a lot of press attention and publicity.

One of the many factors for its success is its distinctive architectural features which include what the Bullitt Foundation, owner of the building, termed an “irresistible”\textsuperscript{46} stairway: a glass-enclosed stairs with panoramic views to entice people to walk instead of taking the elevator. Another factor would be its highly-visible downtown location at the intersection of Capitol Hill and Central District and easy access to transit. The strongest factor in the Bullitt Center’s success, however, lies in the strength of the Bullitt Foundation’s vision in using the Center as a working model for future projects and its commitment to share data and lessons


learned with the community from initial design to end-user occupancy to find ways to enhance long-term building performance in the Northwest. Part of this commitment includes proactive education outreach initiatives such as free daily tours (that are sold out well in advance), community design workshops and designing the lower two floors as learning spaces and classrooms for students to have hands-on explorations of the latest technologies and systems.

**Is the local development community resistant to new construction methods?**

In general, the local development community in Seattle has been relatively open to new and greener approaches to building as long as those changes can be proven to be cost effective, given the small but increasing number of ZEBs in the region. Most resistant to change are the appraisal and financial industries, due to the difficulty in predicting the financial performance and value of new and relatively unproven building strategies and energy generation systems. According to Jonathan Heller, an experienced principal engineer at Ecotope\(^47\), mechanical engineers are also noted for their resistance to new building methods as they are an extremely conservative group. This may be due to the difficult nature of their work which involves high-level, demanding technical knowledge and attention to detail, on which “they will get blamed if things do not perform perfectly.”\(^48\)

Most developers do not want to be the first to try different ways of constructing buildings as the development process itself involves high levels of risk and volatility, but they are relatively open to new construction methods as long as the return on investment (ROI) is justified. However, there are some professionals who want to be seen as leaders in green building innovation, particularly architects and building design engineers, who are generally familiar with the latest energy-efficient technologies and alternative energy sources such as solar and wind. Yet, as integrated building construction practices such as building information modeling (BIM) and measurement and verification (M&V) become more standard in zero energy projects, the pace of change and level of uptake is still insufficient to adequately address climate change issues. It also takes a particularly mission-driven pioneer like the Bullitt Foundation to finance

\(^{47}\) Ecotope is a mechanical and industrial engineering firm based in Seattle that specializes in sensible and cost-effective integration of energy efficiency into all aspects of building design, maintenance and operations.

and underwrite the current cost premium for a building such as the Bullitt Center in the post-2007 recession climate.

**Do local building owners and users lack knowledge of green buildings and their value?**

Building owners are generally aware of the cost benefits of sustainable properties such as the additional increase in building value and a higher ROI, though they may lack real knowledge about the social and environmental benefits of green buildings, the different between available performance standards and how ‘green’ features operate.

According to the results of an ongoing study began in 2009 involving CBRE, the University of San Diego and McGraw Hill Construction based on a national office portfolio managed by CBRE, building owners anticipate a 4% higher ROI and an additional 5% increase in value for green buildings. Approximately 80% of owners surveyed believe that sustainable buildings perform well in attracting and retaining tenants, bringing a 5% increase in occupancy and a 1% increase in property rental income. When asked about why they chose to pursue green building certification, 80% of owners cited energy reduction reasons and 72% cited competitive advantages from offering ‘green’ features, revealing that their decisions are driven most by business goals rather than social benefits or being in compliance with government regulations.

On the tenant side, 61% of tenants agree that a green office space is important for current employees (Figure 7) and 74% believe that green building certification produced higher employee engagement, revealing that demand for green buildings from tenants in the market is strongly present. The strong tenant demand does not yet equate to a willingness to pay more rent, however, given that only 14% of tenants would pay 2%-3% more for sustainable features. From a ZEB perspective, the awareness of the benefits of green building features is a critical issue that is just starting to be addressed in the marketplace. Thus, the education of the advantages of working and living in a green building should also not just be focused on owners and users but all parties associated with the maintenance of the building as well, such as property managers and facility managers.

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II. Financing Barriers

*Has the local financing community developed a generally-accepted way to value ZEBs?*

The financing community can be broken into two sectors: 1) traditional lending and institutional investors and 2) appraisers, both of which have not developed standard methods to value commonplace green performance standards such as LEED and Energy Star in buildings, much less ZEBs. On the banking and investment side, one of the first challenges encountered is the inability to name and define the exact ‘value’ of a sustainable building, given that the social and ecological benefits derived from them are subjective and hard to quantify in monetary terms. This challenge is further exacerbated by the inability to link and incorporate these social and ecological benefits to recognizable conventional real estate financing and valuation models, which reduces the confidence of the lending industry in proposing and marketing these difficult-to-capture factors as competitive investment opportunities. Hence, the driver is for new investments are almost always based on ROI, which is driven by net operating income (rent) and substantially easier to measure than occupant health and reduced carbon emissions.

Secondly, the lending industry is known for providing financing for buildings based on conventional and time-tested methods of financial performance, being traditionally conservative and slow to adapt to new development practices. Banks also prefer to base their investment practices on projects models that have a track record of success, oftentimes only in areas and communities that they have a vested interest in. While there were a number of early adopters and advocates for high-performing green buildings such as the Rocky Mountain Institute, their focus

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50 Ibid.
was primarily on natural and environmental characteristics, as opposed to financial. Consequently, the type of data that is required for financial assessment was not initially gathered or analyzed during that period of growth. In the case of ZEBs having been relatively recently introduced to the building industry, the lack of data and the insufficient time frame against which a substantial number of similar transactions and cycles can be compared are strong reasons for the general reluctance of the commercial lending community to finance ZEB developments.

Thirdly, current lending practices only reflect construction and hard costs in the built capital portion of a project but not the value, energy savings and capital costs of providing the resource to end-users.\textsuperscript{51} For example, if a building were to use energy sources from biomass to power its operations, only the cost of the biomass power plant and the infrastructure to transport it to the building would be calculated in the pro forma. However, the power plant and infrastructure itself is of not much use unless there is biomass to fill them. Hence, a method for accounting for natural capital sources is still needed to accurately reflect the true value of a sustainable building.

In the appraisal community, with very few exceptions, the basis upon which most investments in the US are analyzed is “market value”. Market value, according to the Uniform Standards of Professional Appraisal Practices (USPAP)\textsuperscript{52} mentioned in the 13\textsuperscript{th} edition of The Appraisal of Real Estate, is described as “a type of value, stated as an opinion, that presumes the transfer of a property…as of a certain date, under specific conditions set forth in the definition of the term identified by the appraiser as applicable in an appraisal”\textsuperscript{53} Market value is determined upon determination of the property’s “highest and best use” analysis which includes the physical use, timing of use or market participants associated with the use of the building (other users and buyers). These qualitative and quantitative factors are translated into terms that are monetized in order to estimate market value. In this manner, green building strategies and benefits must also be monetized in order to capture their value, given the valuation methodology used by


\textsuperscript{52}Uniform Standards of Professional Appraisal Practice are the generally-accepted standards of the appraisal profession as determined by the Appraisal Foundation, a body authorized by Congress as the source of appraisal standards and appraiser qualifications.

appraisers, which strongly relates to the challenge faced by lenders.

For both the lending and appraisal groups, however, the biggest barrier to valuing high-performance projects is the dearth of market data and reliable information on the operational performance and transaction expenses of these buildings. At present, cost estimates of a high-performance green building are based on hypothetical energy design models and optimized baselines, which leaves room for subjectivity and technical errors. Even in cases where strong initial attempts are made to quantify total initial incremental costs and savings for the building, the numerous design revisions that are occur before completion are often not tracked through to the final stage, which may contribute to inaccurate estimates. All these factors pose great challenges to reaching realistic and accurate estimates of the market value of a high-performing building before it is built, resulting in the current inconsistency and hesitancy in the attempts of the financial community to analyze the benefits of investing in sustainable real estate and zero energy buildings.

**Are there perceived financial and insurance-related risks for ZEBs?**

As mentioned previously, lenders are very risk-averse, thus new models with relatively few track records of performance such as ZEBs will be perceived as risky. The typical building loan is based on the amount of income the owners are likely to generate from rent. As every new building technology system inevitably experiences glitches when first introduced, the chances of owners paying banks back in a timely manner are lowered with the adoption of new systems that have significantly higher marginal rates of error than conventional ones, thus increasing financial risk and uncertainty to lenders. Hence, there will always be a need for pioneers to find creative ways to work through the initial risk and difficulty of introducing ZEBs as a viable, workable model.

In the case of the Bertschi School, all design fees for the project were provided pro-bono. During the design stage, Skanska estimated that these pro-bono design services would save the school almost US$ 300,000, although the actual savings totaled US$ 570,000 as project partners spent more time on the work than originally anticipated54. In addition, the general contractor Skanska removed their profit and contingency and provided countless donations in both time and

materials for construction. Numerous subcontractors also donated time and materials. The total construction cost was provided through community fundraising led by Bertschi School, who viewed the additional sustainable features as a symbolic part of their mission and vision.

The Bullitt Center, however, is unique in the sense that it had an extremely engaged owner and donor, the Bullitt Foundation, who had funding sources to cover the additional costs of features that are symbolic of the organization’s mission. The project’s sources and uses indicate an equity contribution of $14,500,00 or 48.3% from the Bullitt Foundation, almost half of the $30,000,000 total development cost (TDC), rare by most development standards. According to Denis Hayes, the Foundation’s president and CEO, it took some time for the development team to find a bank that was willing to lend it enough to cover half of its construction costs. The team finally received a loan from U.S. Bank that amounted to 36.7% or $11,000,000 of the TDC. To cover the ‘gap’ in financing, the team received $3,500,000 in New Market Tax Credits or 11.7% of TDC and applied for a U.S. Treasury 1603 Grant, which provided the final 3.3% or $1,000,000 for the project.

In terms of insurance-related risks for ZEBs, the perceived risks are very similar. Insurance is offered with the expectation that nothing will go wrong in the implementation of green structures, building materials and systems, or that if anything does; these problems will be minor enough that the fix will cost less than the accumulated premiums. Other risks involved in ZEBs include defective materials, building failures and materials fraudulently represented as ‘green’. Some insurance companies such as Fireman’s Fund, Zurich, Liberty Mutual and AAIS offer discounts for LEED-certified residential homes or commercial buildings as third party certification is considered to be a desirable aspect in risk mitigation, hence lowering the risk factor. However, newer, more complex performance standards such as ZEBs will likely see a gap in policies for a while as they need additional momentum and time to be recognized by

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55 Refer to Bullitt Center sources and uses under “Costs” on page 19.
57 The U.S. Treasury 1603 payment’s purpose is to reimburse eligible applicants for a portion of the cost of installing specified energy property used in a trade, business or for the production of income. It is made after the energy property is placed in service.
insurance companies as successful mainstream green building strategies. In general, perceived performance risk with new technologies generally raises the rate of insurance, especially if there is a performance guarantee to be provided.

III. Regulatory Barriers

Are there zoning or building codes that present conflicts to ZEBs?

The easiest and most frequent source of on-site power generation for ZEBs is via solar PV. As solar panels take up a significant amount of rooftop space to generate enough power to get to net zero energy level, ZEB project teams have to navigate through regulatory barriers to get zoning and building code approvals or exceptions from the city. According to the Seattle Municipal Code\textsuperscript{59}, solar shading ordinances in the City of Seattle can limit the installation of solar collectors on roofs in the following ways:

1. In Low Rise Zones: The structure exceeds 4 feet above the maximum height limit or 4 feet above the height of the elevator penthouses.
2. In Mid Rise and High Rise Zones: The structure exceeds 10 feet above the maximum height limit or 10 feet above the height of the elevator penthouses.

Building code exceptions for solar PV that exceed these height limits are only granted when the following conditions are met: it meets minimum energy standards, there is no feasible alternative solution to placing the solar collectors on the roof and the PVs are located so as to minimize view blockage from surrounding properties to the north, while still providing adequate solar access for the solar collectors. Given the dense existing urban conditions and hilly landscape of Seattle, not to mention its Comprehensive Plan which calls for increased density to reduce sprawl and automobile travel distances and pollutants\textsuperscript{60}, these height limits could be particularly problematic as taller neighboring buildings could easily block solar access for the ZEBs that rely heavily on extensive solar power to operate. Similar principles apply to on-site wind turbines used to convert wind into energy. Other than height limit conflicts to on-site

rooftop power generation, existing building codes do not generally present challenges for ZEBs since they typically address life and safety issues that all types of new construction must address.

In 2009, however, the City of Seattle passed an ordinance to establish the Living Building Pilot Program (as previously mentioned on page 14). Development standard departures such as allowing building height to both accommodate higher floor-to-floor depths for greater sunlight penetration and the addition of PV arrays above typical building height allowances were provided to the first twelve developers seeking at least 60 percent of Living Building Challenge requirements. The scope of departure allowed floor area ratios up to 15 percent above the otherwise acceptable limit and rooftop features extending more than 10 feet above the otherwise applicable limit, thereby creating more leasing spaces to defray the cost premium of building zero net.

As of May 13, 2013, only three such projects have been attempted despite the call for twelve, with varying degrees of success: The Bullitt Center (completed), Skanska USA’s Stone34 mixed-use four-story development (planning stage) and the Schemata Workshop’s co-housing project in the Capitol Hill neighborhood (planning stage). The Bullitt Center, which officially opened on this year’s Earth Day, April 22, used the Pilot Program to great effect. As the estimated PV square footage for the 50,000 SF building was 14,000 ft², or 250,000kW/year, the design concept required the rooftop solar array to extend out over the public right-of-way, requiring a change in the right-of-way and street improvement that do not typically allow the installation of fixed building elements. The development team successfully requested and received permits for these changes by working closely with the Seattle Department of Planning and Development.

Unlike the Bullitt Center, Skanska’s Stone 34 development initially sought zoning departures under the Pilot Program but had no intention of going far enough to get the building certified under the LBC. This elicited negative reactions from South Wallingford residents, who feared that the increases in building height would block private views. As a response, the Seattle

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City Council voted to extend the Pilot Program for another three years and tighten the LBC requirements in July 2012. The existing 60% LBC requirements were amended as “Deep Green” projects, and limited to a maximum of three developments. The amendments provide the option of 20 feet of additional height above the base zoning, instead of the 10 feet approved in 2009. In addition, the proposed added incentives only apply to buildings that are in Industrial Commercial (IC) zones located in urban villages or urban centers, making the Stone34 eligible as a “Deep Green” project. Despite mixed reviews from the neighborhood, the City Council has also voted to give Skanska an extra 20 feet of height above the 45 feet zoning height on the basis that the extra height is needed to make the building economically viable.

The addition of the “Deep Green” level reflects the pioneering nature and strong commitment of the City of Seattle to address regulatory barriers to ZEBs, despite the controversy, slow uptake and the need to constantly adapt and adjust to development limitations and local realities. In that sense, the Living Building Pilot Program has been a success.

**Are there utility codes that present conflicts to ZEBs?**

The 2009 Seattle Energy Code has been generally supportive of ZEB developments as Seattle City Light provides provisions for two-way or reverse metering of electricity, which provides ZEBs credit for energy sent into the grid when more power is being generated on-site than what is required by the building. The energy code also has alternative pathways that can circumvent prescriptive requirements, such as glazing to surface area limitations. Currently, the city is in the process of finalizing amendments to the Draft 2012 Seattle Energy Code, which will only affect commercial buildings. Permit applications filed after September 1, 2013 will fall under the new code. Changes in the code will affect ZEBs in the following ways:

- **Renewable energy requirements and solar-ready roofs:** The 2009 code requires new buildings to incorporate renewable energy production into the building. However, developers are allowed to purchase renewable energy credits (RECs) as an alternative to on-

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site production. The new code will reduce the amount of renewable energy required and eliminate the REC option, with the goal of encouraging developers to pursue more rooftop solar and hot water heating options. Contradictorily, the draft code includes a provision for new buildings to be ‘solar ready’ \(^{65}\), with the acknowledgement that solar is not yet cost effective in Seattle. This may create a perception among developers that solar PV panels are expensive and not worth pursuing, thus discouraging further ZEB developments.

- **Commissioning the building:** The 2009 energy code has made commissioning \(^{66}\) a requirement, but the new version intends to strengthen these requirements, given that a significant amount of potential energy savings from energy-efficient equipment is ultimately not realized as building occupants do not use or maintain the systems correctly for optimal performance. As commission pays for itself in the long-run, but is not cheap, posing further challenges to the affordability of zero net construction.

**What is the nature of the relationship between the ZEB project teams and the local government?**

The City of Seattle and the Department of Planning and Development have been advocates for sustainable and zero energy projects for 15 years running and are generally willing to support ZEB endeavors as long as they are fully included in all stages of the process. The City continues to review its processes and regulations to remove barriers to ZEBs through a particularly innovative program known as ‘Priority Green’ \(^{67}\), which is broken down into three tiers:

- **Priority Green Expedited** aims to shorten building permit review times for projects that meet typical green building standards, typically used for new single-family, multi-family and non-residential projects.
- **Priority Green Facilitated** aims to give priority review for innovative projects with potential code challenges such those under the Living Building Pilot Project.

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\(^{65}\) Solar Ready in this case requires that new buildings maintain a solar zone and be built with the conduits in place that would make PV installation at a later date less expensive.

\(^{66}\) The concept of commissioning is to ensure that systems installed in the building are functioning and that people who will be managing the buildings know how to use them. It is done by an independent third-party consultant who contracts and reports directly contracted to the building owner.

- **Priority Green Tools** aims to provide ‘incentive fact sheets’ identifying assistance available from city, state and federal resources specifically aimed at sustainable projects being constructed in Seattle.

In the case of the Bullitt Center, the design and construction team worked very closely with Department of Planning and Development to identify code barriers and facilitate the review and approvals process. In addition, the Department of Parks and Recreation has been an active participant in efforts to work through issues concerning the redevelopment of the adjacent McGilvra Place Park and the potential green street on 15th Avenue. Similarly, Skanska worked directly with the Department of Planning and Development and the Seattle City Council to make Stone34 a Deep Green project and eligible for height departures. The Bertschi School, however, face some challenges as they were often the first to discover discrepancies between LBC criteria and building codes. A particular issue the team struggled with was the use of galvanized metals for electrical conduit. Despite presenting numerous non-metal alternates such as fiberglass, the products were rejected by inspections and code officials each time. A compromise was eventually reached with the temporary exception for galvanized metals long as the metal does not come into contact with water or earth or not located on the exterior of the building.

IV. Geographic Barriers

*Does development density and dense urban conditions present barriers to ZEBs?*

The scale of an individual building is driven by the demands for energy generation, thus requiring most urban sites to have a building of more than 5-7 stories in order to justify the high land cost. This makes solar generation via PV and zero net more difficult to achieve in the denser, developed parts of the city due to inadequate roof space, further encouraging the development of low-density low-rise ZEBs with large roof areas in the suburbs. Tall buildings and skyscrapers also present challenges to ZEBs as they can tend to shade parts of all of a neighboring roof for major portions of the day. According to Peter Dobrovolny, a green building expert at the City of Seattle, 7 stories should be the maximum height for an urban ZEB\(^68\), even with very aggressive energy conservation requirements, as it will be difficult to find suitable

\(^68\) Dobrovolny, Peter. "Questions on Net Zero Developments." E-mail message to author. March 21, 2013.
infill land sites for ZEBs. Issues of ownership, crossing of properties and public right-of-ways will not present a challenge for individual ZEBs in terms of on-site generation as conventional connections to utility transmission sources will suffice.

A more sustainable, high-density approach could be achieved through a multi-building or district system that shares a centralized renewable energy production system without requiring individual ZEBs to develop their own small-scale solutions.\(^6^9\) However, it is difficult and complicated to share energy systems across multiple buildings with multiple owners in dense urban conditions. Legal contracts have to be agreed upon, physical systems have to be installed on private property, and complex energy flows must be measured and assigned value. Individual building owners also have to be convinced to buy-in to the long-term economic viability of the entity owning and operating the multi-building system. Issues of ownership, crossing of properties and public right-of-ways will present significant barriers for the installation of zero energy multi-building systems in urban districts due to potential traffic disruptions, damage to existing underground utilities, conflicts over site emissions, fuel delivery and disruption of neighborhood aesthetics.

**Does the local climate present challenges to ZEBs?**

There is the perception that the many days of cloudy and overcast conditions for half or more of the year in Seattle make on-site energy production via PV in ZEBs a tall order. However, solar experts note that the extended hour of sunshine during the summer months in Seattle make solar energy a generally viable option on an annual basis. According to the Renewable Northwest Project, a nonprofit organization with a mission to promote the expansion of environmentally-responsible renewable energy resources in the Northwest, the Seattle area receives almost half as much solar energy as the deserts of California and Arizona, and more sun than Germany, which has established itself as a worldwide solar energy leader.\(^7^0\) The U.S. Department of Energy has also selected Seattle as one of the 25 Solar America Cities across the country based on its long-term commitment to promoting solar technology adoption at the local


level. In Seattle, the altitude of the sun in the sky and the extent of shadows across a property range from 18 degrees above the southern horizon at noon in winter (December 21), to 66 degrees above the southern horizon at noon in the summer (June 21). Figure 8 below illustrates this visually:

![Figure 8. Solar altitude for Seattle (47.6 degrees north latitude)](image)

For greatest year-round energy collection, the optimum tilt angle for solar energy systems is to tilt the collector at an angle equal to latitude. Tilt angles for solar collectors is measured from zero degrees to 90 degrees (perpendicular to the ground or a flat roof). In Seattle, most of the solar resource is available in the summer months, so an angle closer to 30 degrees is recommended for greatest solar energy generation. Even a tilt angle of 72 degrees to capture the most sunlight available at the winter solstice when the sun is lowest in the southern sky reduces generation by only 17%, making solar a convincing case for ZEBs in Seattle since the dense urban conditions and infill plots may leave less flexibility to owners in terms of existing roof angles and orientation. In addition, solar panels operate more efficiently in cool, mild climates such as Seattle and produce energy even under cloudy skies, making the system a workable, viable one for ZEBs.  

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In the case of the Bullitt Center, solar PV is predicted to work remarkably well in bringing the building to net zero energy. The building can fit 14,303 ft² or 575 solar panels onto its roof, which translates to a maximum energy production of approximately 250,000kWh on average per year, which equates to an Energy Use Intensity (EUI) of less than 20kBtu/ft². The proposed EUI for the building, however, is only 16kBtu/ ft² per year (Figure 9) when combined with the efficiency measure of maximizing daylight and the use of daylight sensors and dimming to ensure no more lighting is used than necessary, which makes the Bullitt Center 83% more energy-efficient than the typical Seattle office building. It is also interesting to note that the major design driver for the project was how to solve the energy balance to achieve zero energy. After the design team reviewed all options for on-site renewable energy, solar electricity made the most sense and the strategy was adopted, thus paving the way for the building’s distinctive, low-laying, flared rooftop.

![Figure 9. Bullitt Center Energy Use and Solar Budget](http://www.millerhull.com/html/nonresidential/Bullitt.htm)
Conclusion

The goals of this research paper were to analyze and distinguish the various types of zero energy buildings, their global and local market prevalence, and to pinpoint the barriers that are currently preventing ZEBs from being established as the industry standard and how these challenges have shaped the outlook of the green building industry in Seattle as it is today. With the help of primary data received from subject informants, access to financial information of built ZEBs and the latest net zero research sources, the degree as to how each of these barriers affect the development of ZEBs can be determined.

In particular, the lack of a generally-accepted method to value ZEBs, perceived financial risk and cost issues seem to be the three strongest concerns about the feasibility of ZEB developments. Also eliciting substantial concerns are the issues of on-site rooftop power generation in densely-developed urban areas and utility loads for larger buildings.

To a lesser extent, the exposure and presence of ZEBs in the Seattle market does not seem to be a problem among the local development community, who are generally willing to embrace new methods of construction and are familiar and knowledgeable about green buildings and their value. Neither does the often overcast and drizzly climate of the region seem to be a challenge in generating adequate, if not surplus power for ZEBs. Last but not least, the City of Seattle and its municipal counterparts have also demonstrated their willingness to amend regulations to encourage the development of more zero energy projects, resulting in much time, money and effort saved on the part of developers in getting local zoning, building and utility codes approvals and exceptions.

Despite the early examples of net zero and the growing recognition and demand for these buildings, cities have a long way to go in order before they are able to successfully incorporate ZEBs as significant components of their future sustainability goals. In order to proceed, cities have to understand how to structure incentives more effectively using lessons learnt from early examples and recognize ZEBs not just as individual green buildings but meaningful, long-term asset investments capable of contributing to the health, vitality and viability of a community.
Financing and Policy Recommendations – Overall

Given the inconsistency in ZEB valuation methods and bureaucracy issues associated with policy, how do we even begin to unite the financial and policy sectors on a common platform to support the implementation of more zero net projects? I am in strong favor of the integrated real estate investment model (IREIM) idea proposed by The Economics of Change, a groundbreaking report written in October 2011 by Earth Economics, Cushman and Wakefield, The Bullitt Foundation and Autopoeisis. The IREIM links a conventional real estate pro forma to ecological and social costs and benefits, which are typically valued at zero or omitted altogether from cost analyses.74

In the creation of this new model, ecological and social cost-benefits are quantified in explicit monetary terms and incorporated as line items on a pro forma so to enable these factors to be valued on the same level as traditional financial concepts such as income and expenses. Ecological benefits can include but are not limited to transportation and energy incentives, materials provisions and carbon credits whereas social benefits are more focused on worker productivity, well-being incentives, aesthetics and placemaking incentives. The IREIM, laid out in this manner, then becomes a strategic mapping tool as to which ZEBs and other green building methods can be analyzed for weaknesses and strengths, thus making it easy to identify areas of improvement and new ways to create value from past failures.

Within the IREIM framework, various policy and regulations regarding net zero can be tested and analyzed in terms of how they affect financial metrics such as loan to value (LTV), ROI and internal rate of return (IRR). With the above information, the best policy for investment can then be chosen and implemented through incentives that support the legislation, advocacy, research and development of ZEBs in an efficient and cost-effective manner.

Policy Recommendations – Local Level

**Municipalities**

Local governments can add value to the development of ZEBs by setting ambitious yet reachable goals in their sustainability plans for the city, refining them according to reality and keeping these plans unaffected by changes in leadership. Intermediary initiatives such as Seattle’s “Deep Green” level should be strongly encouraged and can be amended once ZEB developments become more commonplace. Another good strategy is to keep the process of getting zoning and building code approvals as consistent and accessible as possible. Having a point person of contact at the Department of Planning that specializes in ZEBs would definitely make the entitlements and due diligence process easier and shorter for all parties involved.

As one of the key difficulties in development is obtaining financing, municipalities can compile an open “funding table” or a list of current ZEB project profiles in the city that are awaiting investment opportunities, from which financial investors such as banks, foundations, pension funds and life insurance companies can choose to invest in if interested. Local governments should also consider the creation of financial mechanisms or vehicles that allow the harnessing of a portion of the future stream of revenue and energy cost savings to finance the upfront costs for developing ZEBs. Existing financing mechanisms such as Tax Increment Financing (TIF) districts and Payment in Lieu of Taxes (PILOTS) can also be amended by incorporating sustainability features into the cost savings.

Cities can also help by providing technical assistance and support to developers interested in learning about and pursuing net zero on a one-to-one basis, tailored basis. Last but not least, local governments can try to implement a carbon tax on the worst polluters to pass back to ZEBs so as to minimize negative externalities on city inhabitants.

**Building Users**

Building users and occupants too, play a role in encouraging the widespread development of ZEBs. In Seattle, powering a five-or-six story building using only solar panels on the roof means using less electricity than the average office building, thus requiring a change in occupant behavior and lifestyle habits. These changes do not have to be drastic; rather, small
improvements such as using alternative modes of transit to reduce the number of parking spaces needed on the building lot, unplugging loads from electrical outlets and powering down computers at the end of the day may add up to a substantial amount in reducing energy consumption habits; thus making net zero status easier to achieve.

**Private Sector**

For private sector professionals such as developers, bankers, appraisers and designers, having a fully-integrated design process with clear objectives throughout the project lifecycle is one of the strongest ways to ensure the success of net zero projects. Subsequently, developers should make an effort to learn about and pursue all available incentives and tax credits for ZEBs, which can be of immense help in making the project an attractive, feasible investment opportunity. Some examples of these incentives include renewable energy tax credits, federal and state historic tax credits, new market tax credits, energy-efficiency loans and green mortgages.

Apart from that, developers could also become strong advocates for ZEBs by committing to share data on successful projects with the public to make the business case for net zero and further build the standard’s credibility among the financial community. On the lending side, bankers could come up with new “patient long-term capital” products that would allow the ROI of ZEBs to be lower than current market rates for a certain number of years before making the “transition” back to high yields. Last but not least, designers could start thinking about how to incorporate ZEBs on a multi-building or district scale so as to enable ambitious, whole-system concepts such as net zero carbon to reap the benefits of scale economies.

Ultimately, the most effective way to make ZEBs a reality is to align missions of all parties from the very beginning, communicate a clear set of goals to be achieved and ensure a common understanding and consensus along every step of the development process.

**Client Benefit**

What could Mithun do with this research data? The firm could continue efforts to build the “knowledge” component of the firm by using this paper as a starting point for more detailed
investigations on specific components of ZEBs in the form of articles, blog posts, reports and white papers. Being an active participant and speaker at Living Future Conferences, Mithun could continue to share these results in addition to data from its own past zero energy projects with other trade and industry associations with a vested interest in ZEBs such as the Cascadia Green Building Council, the American Institute of Architects, Urban Land Institute and the U.S. Green Building Council. Apart from that, the framework for analyzing challenges to net zero could be used as a strategic plan for future projects in other cities. On a state and national scale, Mithun could tap into its strong network and influence to recommend policy changes and potentially collaborate with organizations such as the DOE Building America teams such as the Lawrence Berkeley laboratory to conduct further groundbreaking research on ZEBs.

Further Research

For additional research on the topic of zero energy buildings, interested parties should consider learning about and implementing Net Zero Ready as intermediary step, if Net Zero is not an immediate possibility because of timing and cost issues. Net Zero Ready projects are buildings that have the potential to be completely net zero at some point in the future with the addition of just one or two steps, typically with conventional mechanical systems such as solar PV. The EUIs of Net Zero Ready buildings are generally in the range of 20KBTU/SF/year and can be considered ‘ultra low energy’ projects. Two such projects in Washington State are the Rice, Fergus, Miller, Office and Studio in Bremerton, WA and Firestation 72 in Issaquah, designed by Ecotope Engineers. For those who have successfully built a Net Zero project, a concept to consider as a future project would be Net Zero Plus or Energy Plus, buildings that produce more energy than they consume on an annual basis.
Appendix

A. Net Zero Development Questionnaire

CLAIM 1: The concept of net zero is new and not completely understood by the Seattle market. [MARKET]
   a. Does technology (or lack of it) in the local market present a barrier to building net zero projects?
   b. Are net zero projects facing a lack of exposure and presence in the market?
   c. Is the local development community resistant to changes in the way that they have built buildings in the past?
   d. Do local building users lack knowledge of green buildings and their value?
   e. Do you know of successful examples of net zero projects in Seattle that overcame market barriers? If you know of unsuccessful examples, what were the reasons for their failure?

CLAIM 2: Net zero buildings are expensive and difficult to finance in Seattle. [FINANCING STRUCTURES]
   a. Has the local financing community developed a generally-accepted way to value net zero buildings? If so, how? If not, why?
   b. Is there a perceived financial risk associated with new and/or untested technologies and systems?
   c. Is there a perceived financial risk with issues related to insurance for net zero projects?
   d. Are there challenges associated with the implementation, zoning and/or cost on-site power generation for net zero projects?
   e. Do you know of successful examples of net zero projects in Seattle that overcame financial barriers? If you know of unsuccessful examples, what were the reasons for their failure?

CLAIM 3: Current public policies and municipal regulations in Seattle do not support net zero projects. [REGULATORY]
   a. Are there particular zoning, utility, municipal or building codes that present conflicts to building net zero? If so, how do they conflict?
b. Do you know of successful examples of net zero projects in Seattle that overcame municipal barriers? If you know of unsuccessful examples, what were the reasons for their failure?

c. For net zero projects that you are familiar with, what is the nature and character of the project team’s relationship with their municipal counterparts or collaborators?

CLAIM 4: Existing urban development and climactic conditions in Seattle make it difficult to implement net zero. [GEOGRAPHIC]

a. Do net zero buildings typically require more space compared to regular buildings?

b. Is development density (infill sites and dense urban housing conditions) in Seattle a barrier to building net zero?

c. Does property ownership, the crossing of properties and/or public right-of-ways present barriers to the production or transmission of energy for net zero buildings?

d. Does the local climate and weather condition present challenges to net zero buildings?

e. Do you know of successful examples of net zero projects in Seattle that overcame geographic barriers? If you know of unsuccessful examples, what were the reasons for their failure?

WORKING CONCLUSION: Cities have a long way to go in establishing net zero buildings as the norm for new construction, but examining early net zero examples can help cities better understand how to best structure incentives and financing to help stimulate these developments as part of their future sustainability goals.

a. What changes in policy should be made to encourage more net zero developments in Seattle?

b. What changes in financing incentives and structures should be made to encourage more net zero developments in Seattle?

c. Are there any relevant project financials or reports and data sources related to the topic that you would be willing to share?

d. Is there anyone else in Seattle that you think I should talk to regarding my project?
B. Bullitt Center Tenant List, Energy Usage Breakdown and Floor Plan

The following is a list of office spaces currently available for lease in the Center:

1st Floor - LEASED
- International Living Future Institute
- University of Washington Integrated Design Lab

Suite 250 - Approximately 2,077 SF
- Located off the Madison Street Entrance.
- Offers 11' clear height ceilings and floor-to-ceiling operable windows.
- Neighboring tenant is the University of Washington Integrated Design Lab.

Suite 300 - Approximately 7,949 SF
- Full floor with a 753 square foot south-facing private outdoor terrace.
- Suite overlooks the McGilvra Place Park and the Center's green roof.
- 16'-0" fully glazed Sliding Door System with glass Juliette balcony railing.
- Exposed heavy timber ceilings.
- 13’ ceiling heights, 4’x10’ operable windows.
- Men's and Women's restrooms with showers and fully equipped kitchen.

Suite 400 - LEASED
- Full floor with City and park views.
- 16'-0” Fully glazed Slider Door System with glass Juliette balcony railing.
- Exposed heavy timber ceilings.
- 13’ ceiling heights, 4’x10’ operable windows.
- Men's and Women's restrooms with showers and fully equipped kitchen.

Suite 500 - LEASED
- Full floor with City views and park views.
- 16'-0" fully glazed Sliding Door System with glass Juliette balcony railing.
- Exposed heavy timber ceilings.
- 13’ ceiling heights, 4'x10' operable windows.
- Men's and Women's restrooms with showers and fully equipped kitchen.

Suite 650 - LEASED
- Top floor with spectacular views!
- Up to 18'-0” ceiling height with skylights throughout.
- 16'-0” fully glazed Sliding Door System with glass Juliette balcony railing.
- Exposed heavy timber ceilings.
- 13’ ceiling heights, 4'x10' operable windows.
- Men’s and Women’s restrooms with showers, and fully equipped kitchen.
- Two large, shared conference rooms.
- Neighboring Tenant is the Bullitt Foundation.