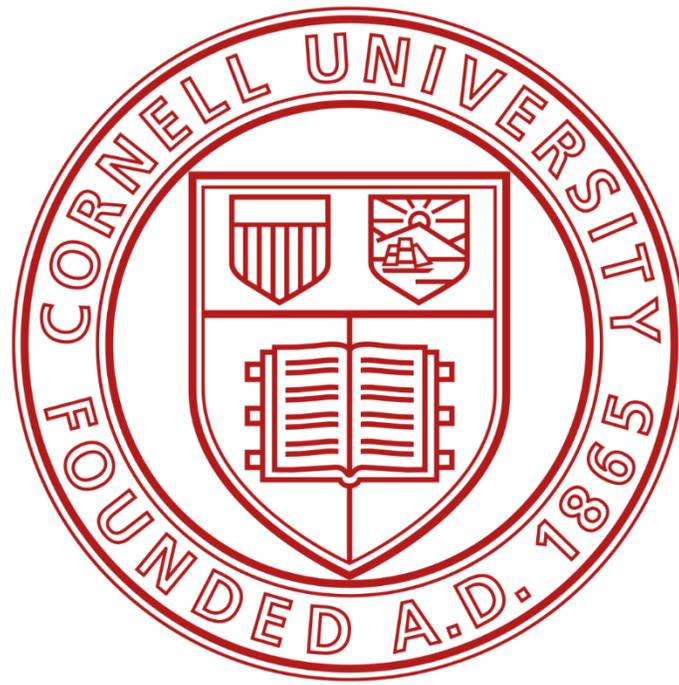


# **An Examination of LEED Certification's Utility as Evidence for Superior On-Property Environmental Sustainability in Hotels**



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Cornell University School of Hotel Administration

May 28, 2017

An Examination of LEED Certification's Utility as Evidence for  
Superior On-Property Environmental Sustainability in Hotels

By

Grant Michael Behnke

A dissertation submitted in partial satisfaction of the requirements of

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Committee in charge:

Professor Christopher Anderson, Thesis Advisor

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The dissertation of Grant Michael Behnke is approved.

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## **Abstract**

An Examination of LEED Certification's Utility as Evidence for  
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This study explores the potential misalignment between LEED certification's prescriptive scorecard and hotel real estate's operationally complex nature. This study revealed that LEED hotels generally outperform their non-LEED counterparts on a per square foot basis for carbon footprint, energy use, and water use metrics, but perform worse on a per occupied room basis. However, the large amount of variance in the data sample that is inherent in hotel industry data renders definitive conclusions about the utility of LEED as evidence for superior on-property environmental sustainability in hotels difficult to make. Any variance between LEED and non-LEED data groupings was generally not found to be statistically significant. These results demonstrate that further analysis is needed before LEED certification can be tied to levels of environmental sustainability between hotels in a meaningful way. Also, the true impact of hotel LEED certification is extremely difficult to find with any method besides direct comparison of hotel metrics before and after LEED certification.

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Thesis Advisor

Date

## **Acknowledgements**

This paper would not have been possible without the unwavering assistance of many professors at the School of Hotel Administration and throughout Cornell University. They spent four years shaping my mind and preparing me to explore this topic thoroughly and effectively. They also helped me to develop my own perspectives and opinions on this topic, among many others, with their willingness to listen to my thoughts and answer my questions. Their hand in augmenting my academic confidence is undeniable, and I am grateful.

In particular, I am incredibly thankful to Professor Christopher Anderson, both for his willingness to step in and be a part of this journey, as well as for all of his guidance and support along the way. He ensured that my research ambitions were never misdirected, both in pursuit of answers as well as in pursuit of questions. He and the rest of the Cornell Center for Hospitality Research offer seemingly endless backing to new industry research. They are willing to accommodate any interest or idea that can help the hospitality industry to progress and innovate on sound foundations of knowledge.

Furthermore, this study would not have been possible without the generous time, insight, and data contributions from Eric Ricaurte, SHA '01, and founder and CEO of Greenview. His hand in the development and management of the Cornell Hospitality Sustainability Benchmarking Tool and his accompanying experience and intuition with sustainability in the hospitality industry were vital resources. Eric's interest in sustainability, enthusiasm for innovation, and constant quest for further knowledge hooked me on this topic and made this project all the more interesting and enjoyable to pursue.

*This work is dedicated to my entire family,  
and especially to Paul William Bortell Jr. and Duane Willis Behnke,  
for their inspiration.*

## **Author's Background**

Grant Behnke is a senior in Cornell University's School of Hotel Administration from Cleveland, Ohio. After arriving at Cornell University with an interest in on-property hotel operations, his interests quickly evolved to include real estate, environmental sustainability, and international development. He explored those interests during internships with Winegardner and Hammons, Rockbridge, and Sunstone Hotel Investors.

Environmental sustainability in the hotel industry is an issue that is both interesting and important to Grant. He expanded his perspective on the hotel industry's role in our world by taking classes through Cornell University's Department of Natural Resources, Department of City and Regional Planning, Department of Romance Studies, and Department of Earth and Atmospheric Sciences, and engaged extensively with the Cornell International Institute for Food, Agriculture and Development and the Center for Sustainable Global Enterprise.

As a student at The Hotel School, Grant was involved as a teaching assistant for numerous courses and served as the President of Ye Hosts Honorary Society. He also held leadership roles in The Hotel School Ambassadors and Hotel Ezra Cornell. Outside of The Hotel School, Grant served as the President of The Men of Last Call, an all-male a cappella group.

Grant's academic work is influenced by his love of music, including performance, composition, and production. Grant also enjoys long-distance running and is a Boston Marathon qualifier.

Grant will graduate with distinction from Cornell University with Bachelor of Science in Hotel Administration, as well as minors in Real Estate and Spanish. Upon graduation, he will join the Investment Management team at Rockbridge in Columbus, Ohio.

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# INTRODUCTION AND CONTEXTUALIZATION

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## **Purpose of Study**

The purpose of this study is to examine the impacts of LEED (Leadership in Energy and Environmental Design) certification on hotels. LEED is focused on physical buildings with its certification scorecard categorizations and focus areas. Hotels impact the environment not only with the design and construction of their physical shell, but also in their operations. Therefore, hotels share a unique relationship with LEED given that many sustainability innovations throughout the hotel industry are oriented toward on-property operations, and less so toward sustainable design and construction, so pursuit of LEED certification forces hotels to think beyond traditional sustainability innovation. Certainly LEED certification is good for hotels to pursue should they choose to do so, given that it has been shown to be beneficial when it comes to guest satisfaction and revenue generation, but given this inherent dichotomy that exists within sustainability in a hotel context, LEED certification may not be as relevant for hotels to pursue because it cannot capture the operational intensity of hotel real estate. Certifying a building's physical shell is not always indicative of truly sustainable operations happening within that shell.

In hotels, sustainability begins with people, so can LEED certification serve as evidence for superior on-property environmental sustainability in hotels? Or is the divide between LEED's building-centric scorecard and hotels' operations-centric sustainability paradigm too great? Given all of the available data in the hotel industry, especially with the recent creation and proliferation of the Cornell Hospitality Sustainability Benchmarking Tool, an examination of how LEED certified hotels perform relative to other hotels that are not LEED certified, based on

traditional sustainability and resource consumption metrics, can help to shed light on LEED's efficacy as a measure of sustainability and the financial and societal benefits that accompany sustainability in hotels.

## **Environmental Sustainability and Sustainable Development in Modern Society**

Today's world finds itself in a brand new age of its relationship with the planet, and as human society approaches an inherently unpredictable future, acknowledgment and understanding of this relationship are vital for success. This new geological epoch is referred to as the "Anthropocene," or, "Age of Man," a term first coined by scientists Paul Crutzen and Eugene Stoermer in an effort to capture the idea that mankind is the primary driver of the planet's climate and geological shifts.<sup>1</sup> This differs from the "Holocene," which is the official term for the current geological period, which began with the end of the Ice Age and marks a period that has seen a general warming of the planet.<sup>2</sup> This epoch is grounded in theories of natural changes in the planet. The "Anthropocene" is a term that is "widely used but not official,"<sup>3</sup> despite the push of the scientific community to change our current epoch's name and recognize the impact that human development has had on the planet and the environment.

Modern society tends to group economics and the environment, aggregate them with social systems, and frame their relationship as a three-legged stool. As author David Greenwood describes, "introduction of the concept of sustainability into environmentally oriented thinking has broadened the landscape of inquiry to include the "three-legged stool" of sustainability: the

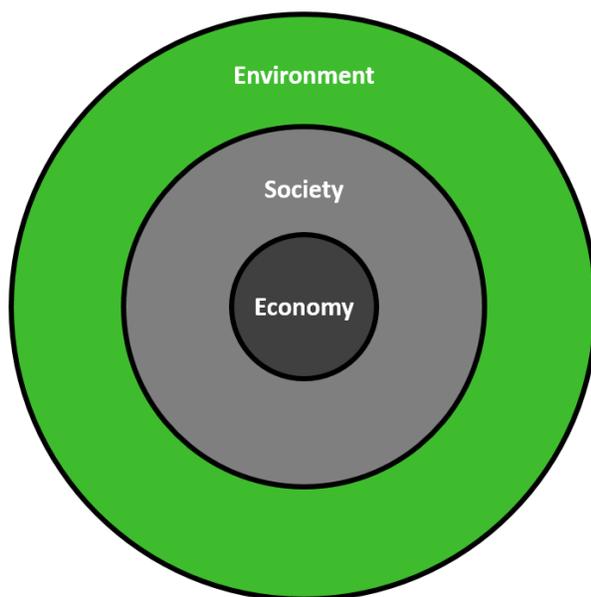
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<sup>1</sup> Crutzen and Stoermer (2000)

<sup>2</sup> University of California Museum of Paleontology, [www.ucmp.berkeley.edu](http://www.ucmp.berkeley.edu) (2017)

<sup>3</sup> Lewis (2011)

environment, the economy, and society.”<sup>4</sup> He argues that this model can help dissuade people from using old economic paradigms of unqualified growth and uninhibited development, because that sort of growth and development impacts society as well as the environment. Greenwood cites our “hyper-individualism, unbounded faith in progress, and extreme anthropocentrism” as the causes of our current environmental plight, especially because these characteristics amplify the effects of the “IPAT” equation and push us further along the path to our own self-destruction.<sup>5</sup> This extreme anthropocentrism is exemplified in our culture in our reliance on the three-legged stool model and the way we tend to remove our economic and societal decision-making from the environment’s needs. However, for the purposes of this paper, it is important to recognize that this may be an inaccurate metaphor.



*Figure 1: Concentric Circle Model of Sustainability  
(custom graphic, 2017)*

The three-legged stool model implies not only that these elements are disconnected parts of the prosperity of the planet, but also that each one carries equal importance to humanity’s success. That is a dangerous ideological outlook. A more accurate metaphor may be concentric circles. A visual representation of this model is shown in **Figure 1**. This is a model in which economic systems exist inside of social structures, and social structures exist inside of

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<sup>4</sup> Greenwood, David A. (2014)

<sup>5</sup> Ibid

environmental needs. This model is also seen as the “Three Nested Dependencies” model.<sup>6</sup> As it relates to the “big picture,” this model is arguably the most philosophically constructive and intellectually honest.

Taking away economics and social structures and leaving only the environment will still allow the planet to thrive, possibly even more so than it does today. On the other hand, by taking away the environment and the inherent support that it gives to our modern economic and social constructs, we would see a rapid decline and disappearance of those constructs. The three-legged stool metaphor only applies today in the sense that, because of the damage we’ve done to the environment, the environment now must rely on social and economic innovation to be saved. With the model of concentric circles, education, innovation, and acknowledgment of responsibility are all required to be able to move in between each circle and hold them all together in a sustainable way.

As a global community, we have a responsibility to each other and to the environment – an idea that is tested every day in every region of the world due to the numerous challenges we face. These challenges include climate change, water security, food system stability, land grabbing, social inequality, biodegradation, pollution, energy production, and many others. Approaching these issues requires a two-prong strategy that includes both increasing resilience to the inevitable challenges that come with living on Earth, and reducing vulnerability to these challenges through education, economic development, thoughtful distribution of resources, and innovative, localized solutions. This two-prong strategy requires buy-in from many different

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<sup>6</sup> Willard (2010)

stakeholders, including governments, businesses, special interest groups, and cultural institutions. Ultimately, taking these challenges on successfully will require a change in the global paradigm of responsibility and sustainability.

Even though many environmental challenges can be tied back to human beings and the development of our modern society, modern society also has a hand in finding solutions to those challenges, and hopefully, manufacturing our own salvation. As Ogden et al note, the Anthropocene can be “characterized not only by the anthropogenic dominance of the Earth’s ecosystems but also by new forms of environmental governance and institutions.”<sup>7</sup> Fortunately, those new institutions and societal developments have been accompanied by human attempts to understand, explain, and adapt our ways to be less environmentally detrimental in the way we live, work, and play. An element of this adaptation has been the emergence of a mindset of sustainable development. Despite this concept being best understood as a high-level cultural paradigm that is generally intangible, it has many policy implications that collectively have catalyzed many critical changes in economic and political spheres, everywhere from the local level to the global level.

Sustainable development can be understood and defined in many ways across many disciplines. The most commonly used definition of sustainable development is the definition created by the Brundtland Commission, formally known as the World Commission on Environment and Development. Their definition appeared in 1987 in *Our Common Future*, a report on the discussion and findings of the commission, whose purpose had been to bring countries together

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<sup>7</sup> Ogden et al (2013)

to discuss the collective pursuit of sustainable development. They defined sustainable development as “development that meets the needs of the present without compromising the ability of future generations to meet their own needs.”<sup>8</sup>

The Brundtland Commission was one of the first examples of global collaboration for sustainability led by the United Nations. Since then, the United Nations has spearheaded further global commitment to sustainable development. This first came as a set of goals known as the Millennium Development Goals, which were developed during the Millennium Summit of September 2000.<sup>9</sup> These goals, which encompass efforts in eliminating poverty, improving health and safety, promoting education, and conserving the environment, had a self-imposed deadline of 2015. In September 2015, the Millennium Development Goals were succeeded by the Sustainable Development Goals. This collection of 17 goals, shown together in **Figure 2**, targets



Figure 2: UN Sustainable Development Goals (UN, 2017)

<sup>8</sup> World Commission on Environment and Development (1987)

<sup>9</sup> United Nations, [www.un.org/millenniumgoals](http://www.un.org/millenniumgoals) (2017)

global issues similar to those that provided a framework for the Millennium Development Goals, but with the addition of focusing on sustainable infrastructure, cities, and energy generation, as well as on the development of partnerships to achieve these goals by their target year of 2030.<sup>10</sup>

An important nuance to be aware of regarding the arguments for sustainability and sustainable development, especially when considering the concentric circle model for the environment, society, and economy, is that sustainability, at its core, tends to prioritize the environment; however, sustainability ideas look to affect sustainability in all aspects of life and the planet. A mindset of sustainability tries to act as a guide toward processes that are environmentally beneficial. However, sustainable development, while intimately related to sustainability, tends to reject the notion of an eco-centric philosophy and instead focuses on human well-being as the true goal of sustainability. Human well-being certainly relies on the health and prosperity of our planet, but in general, the sustainable development paradigm is more interested in ways that humans can prosper alongside the environment, instead of needing to directly adapt our lifestyle to fit the environment, and possibly avoid certain practices and systems entirely due to the environmental harm they create.

Cities and the built environment are an incredibly important part of our society, especially now that we have surpassed a point where more than 50% of the world's population lives in areas that are defined by the United Nations as "urban."<sup>11</sup> The built environment is arguably the most literal manifestation of development. Shifting our focus on sustainability to buildings that we live and work in is highly logical, but as the Sustainable Development Goals highlight, it does not mean

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<sup>10</sup> United Nations, [www.un.org/sustainabledevelopment](http://www.un.org/sustainabledevelopment) (2017)

<sup>11</sup> United Nations Department of Economic and Social Affairs, Population Division (2014)

that the world can turn its back on other important social and environmental issues as we strive for individual comfort and economic gain. As we become more technologically advanced, we can slowly gain increased access to those comforts and gains without harming the environment in the process as well as develop models that incorporate decision making, data, and algorithms to optimize human and environmental prosperity. These ideas begin at the global level, extend down through cities and towns and other tangible elements of human advancement and development, and end up in the sphere of individual responsibility and ethics, and for some, act as a call to action and push for innovation across all disciplines.

The paradox of sustainable development exists within the dichotomy between environmental conservation and economic development. As today's world now finds itself with the power to either destroy itself or create its own salvation, there is an ever-growing need to think critically about ecological, societal, and economic aspects of this sustainable development paradox. Everyone on the planet has an individual ecological footprint, and the time has come to start walking in smaller shoes.

## **Environmental Sustainability in Hotels**

Just as individuals have ecological footprints, so do buildings, companies, and many other entities that create the fabric of our industry, including hotels. Before addressing the specific elements of LEED certification as they relate to hotel building design and operations, it is important to address why hotels should be a focus at all when it comes to sustainability initiatives. Sustainability in hotels has gained momentum over the past decade as operators and owners begin to realize the commingled opportunities for financial and societal success that come with

being a green hotel. Beginning with the qualitative components, hotels and the broader hotel industry exhibit the following characteristics:

- Eagerness to innovate and implement new solutions
- Flexibility for opportunities in design, operations, and technology
- Desire to move as a brand or as an entire industry
- Receptiveness to public perception, both in-person and online
- Willingness to engage with communities and leverage their prominence in the public eye

Hotels are highly attractive components of the urban built environment for social focus and financial investment when it comes to sustainability improvements, both for retrofits and new construction. Their rise as physical structures in cities throughout the world has been noted as the “physical manifestation of a distinctly American vision of mobility, civil society, democracy, and ultimately, space – a vision which, if the subsequent propagation of hotels in virtually every nation and culture on earth is any indication, has shown itself to be quite compelling.”<sup>12</sup> Hotels are social hubs of a city and often are key parts of the built environment for any community, and therefore wield a certain amount of power both as individual properties in a city and as an industry through their sensitivity to public perception.<sup>13</sup> If hotels are pushing a sustainability initiative, then the rest of the city is likely to follow suit with prioritization of sustainable development, green building design, and more broadly, a general cultural paradigm of responsibility for the planet. Hotels have many different managerial levers and components where sustainability can be designed and operationalized, making them exciting arenas for

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<sup>12</sup> Sandoval-Strauz (2007)

<sup>13</sup> O’Neill & Siegelbaum, The Rice Group (2002)

creative solutions to be tested in many iterations regarding operations, design, architecture, management, and technology. LEED certification for hotels is one such solution that requires a multidisciplinary approach to sustainability implementation combined with thorough planning. Lastly, hotels are always looking for opportunities to innovate and to push the industry forward, and are highly likely to move and adapt as an industry, not just as individual properties. If a brand were to roll out a new technology, appliance, management tactic, design standard, etc. to improve efficiency, not only would that brand be able to very quickly implement the new initiative across its portfolio of hotels, but also, the rest of the industry would likely follow suit. This system of leaders and followers leads to much faster uptake of new ideas than if properties operated in a vacuum and initiatives were tested and implemented asset-by-asset on an ad-hoc basis.

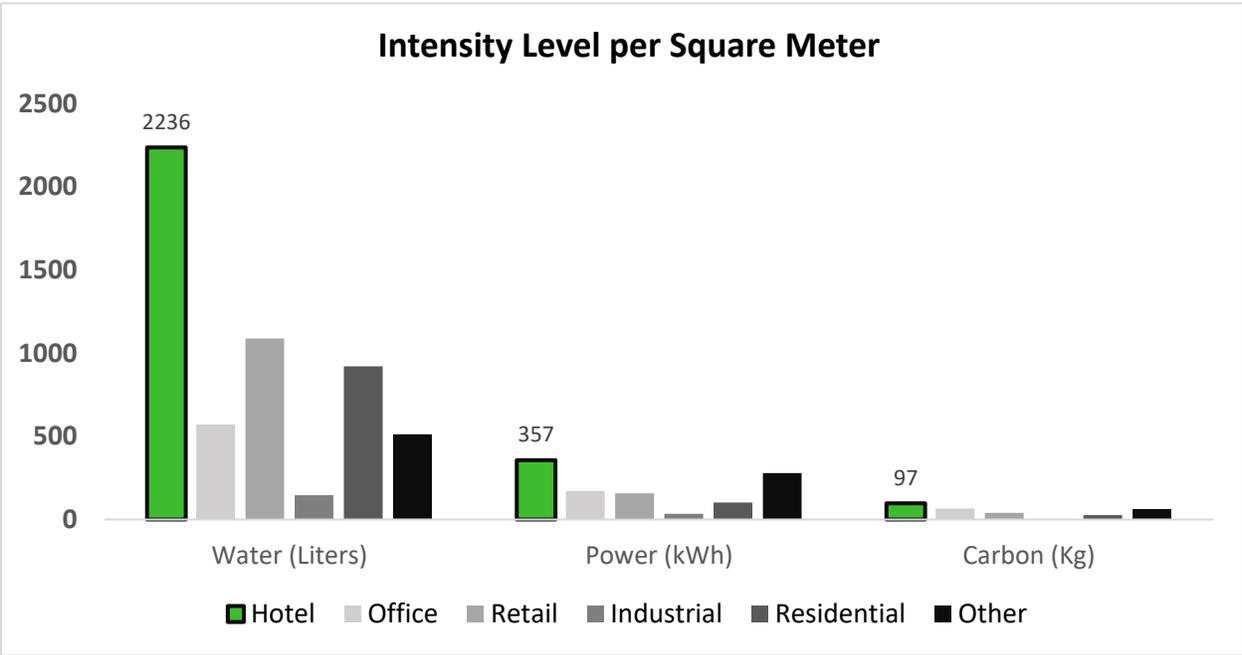


Figure 3: Hotel Resource Use Intensity vs. Other Real Estate Classes (GRESB, 2016)

Quantitative analysis also demonstrates the appeal of sustainability investment in hotels and their attractiveness as targets for sustainability. Hotels are more intense users of water and

energy, and have a larger carbon footprint than any other type of real estate, both in terms of usage per dollar of gross asset value (GAV) and usage per square meter of floor area.<sup>14</sup> This is shown in **Figure 3** and **Figure 4**. To contribute to that discussion, Redefine International’s 2016 Corporate Social Responsibility Report highlighted hotels as the real estate sector that saw the largest increase in carbon footprint since 2015 with a 15% increase in carbon dioxide emissions.<sup>15</sup>

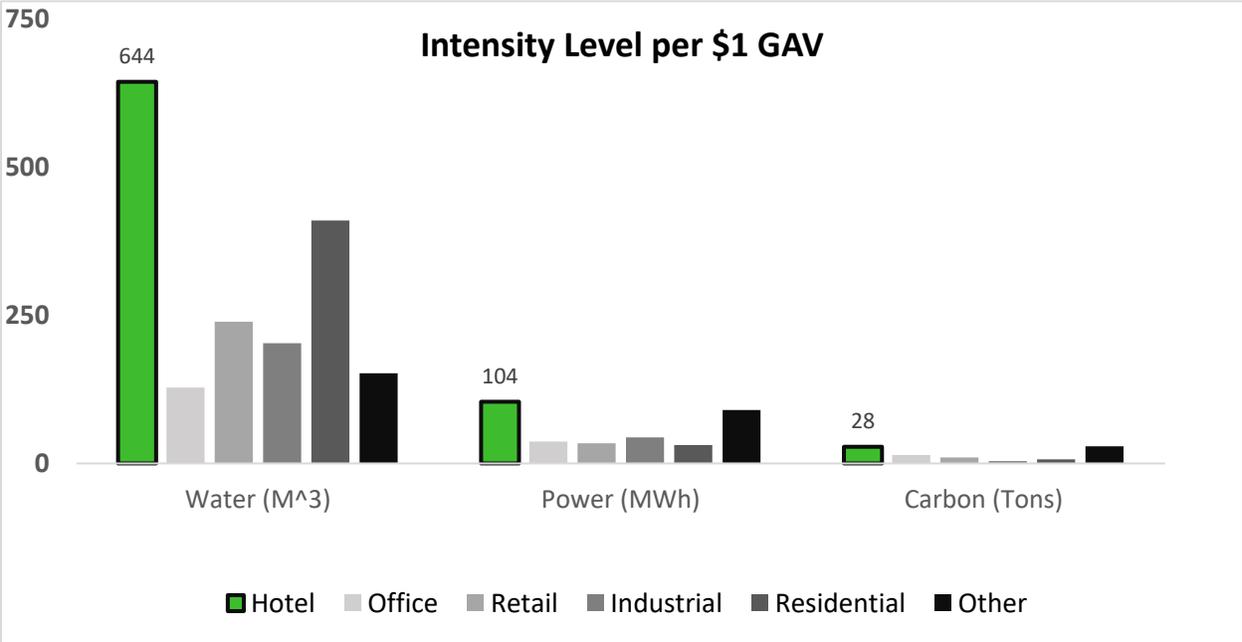


Figure 4: Hotel Resource Use Intensity vs Other Real Estate Classes (GRESB, 2016)

Between those two metrics, it is abundantly apparent that inefficiencies are causing hotels to be enormous consumers of resources beyond what would be considered their “fair share” consumption relative to other kinds of real estate and other components of the built environment. Hotels’ high resource usage intensity may be partly attributed to simply being complex assets with a heavy operational component. It is difficult for hotels and their management to maintain control over the intensity levels of resource consumption at any

<sup>14</sup> GRESB (2016)

<sup>15</sup> Redefine International (2016)

property simply because there are different guests floating in and out at every hour of every day. Guests at hotels have a much different mindset of consumption than they would at home. Various studies have shown that some guests admit to letting go of “green” habits while on vacation at a hotel, even though they would normally do certain “green” steps throughout the day in their normal household setting.<sup>16,17</sup> At home, guests may be more conscious about leaving the water running or throwing food away, but at a hotel, not only are they less conscious because the direct financial consequences of those actions have been removed, but even beyond that, hotel guests expect excess. They want their stay to exude an essence of plentifulness and abundance.

With all of that said, there is definite room for improvement in hotels. The headroom that hotels have available for sustainability improvements make them a clear target for sustainability initiative spending. LEED is one tool that can be used to guide that spending, and ideally, optimize it to minimize the financial stress on the hotel while maximizing the environmental utility of its design and operations. Industry professionals also argue that when it comes to solving issues such as carbon footprint reduction in our planet, money is best spent in the built environment due to shorter payback periods and the opportunity to generate returns on sustainability ROI projects.<sup>18</sup> This is because the money invested can be made back much faster than if it were to be invested in building a wind turbine or conducting research on solar power, for example. While this may not be true on a macro level, when it comes to individual motivation, the built

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<sup>16</sup> Barr, Shaw, and Coles (2011)

<sup>17</sup> Miao & Wei (2013)

<sup>18</sup> Van Oostrom (2016)

environment offers a highly tangible arena for sustainability investment. Hotels should be key targets for sustainability ROI projects, of which LEED is one of the most important to consider.

Hotels are interesting to analyze in the context of the environment because hotels impact the environment during two major phases: construction and operations. These phases are tremendously different but equally important when it comes to hotel sustainability. In an effort to control those two impacts on the environment, hotel owners, operators, and designers have begun to incorporate Corporate Social Responsibility, or CSR, initiatives into their ways of doing business. CSR can help these companies and their partners to maximize the triple bottom line – the business and finance world’s version of the concentric circles of dependency.

Studies have shown that positive and negative impacts of CSR on firm value and financial performance in the hotel industry are not statistically significant.<sup>19</sup> However, there are many reasons for hotel companies to pursue CSR initiatives beyond just financial gain. In reality, though, these are more than just motivating factors – CSR should not be looked at as a “chore” for the hotel industry but rather as an opportunity. Goldstein and Primlani of HVS summarize some of these opportunities well when they report that “the hotel and lodging community is poised to embrace sustainable operation and development as a means not only to preserve our environment, but also to optimize efficiency, realize cost savings, improve employee morale, enhance guest satisfaction, and manage investor expectations.”<sup>20</sup>

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<sup>19</sup> Kang, Lee, and Huh (2010)

<sup>20</sup> Goldstein and Primlani (2012)

One often-overlooked motivating factor for corporate social responsibility and sustainability in the hotel industry is the simple issue of morality. A common phrase that ripples throughout industries and companies undergoing CSR and sustainability overhauls is “doing well by doing good.” For many main stakeholders in the hotel industry, simply doing the right thing is not enough motivation to devote time and resources to “doing good,” but for some, it is enough. Certainly, opportunities for commingled financial, societal, and environment gain are preferred, but not every element of sustainability will be profitable, and it is up to each hospitality leader to decide what the appropriate balance of a cost-benefit analysis should be for themselves, their company, and their properties.

### **Environmentally-Focused Certifications and Ecolabels for Hotels**

Certification, by definition, is the process of providing someone or something with an official document attesting to a certain status or level of achievement. As certification relates to hotels, there are a few options to consider. Hotels can pursue labels or certifications that are specific to tourism and the tourism industry, which is especially applicable for hotels that concentrate on eco-tourism or nature-based tourism. Hotels also have options for labels or certifications that are focused on hotels and their operations and management. Some of these focus on individual properties and their innovations, and others focus on brand-level environmental sustainability and the efforts of a company to implement sustainable hotel operations. Lastly, hotel designers, developers, managers, or owners can choose to pursue one of many different green building certifications available to them throughout the world, one of which is LEED certification. Overall, these certifications can help to differentiate a hotel from its competition, substantiate its

commitment to sustainability, and serve as an information provider to guests, owners, and operators looking to involve themselves with a particular property.<sup>21,22</sup>

Environmental certifications and so-called “ecolabels” have proliferated throughout the tourism and hotel industries over the past couple of decades, as well as in the green building industry in general<sup>23</sup>. Despite their popularity among tourism organizations, nature-based tourism operators, and hoteliers, certifications focused on tourism will not be a focus of this paper, nor will the tourism industry in general, despite the intimate connection that the hotel industry shares with the tourism industry.

According to the Center for Ecotourism and Sustainable Development, environmental certification programs started in 1992 at the “Earth Summit” held in Rio de Janeiro by the United Nations. This meeting resulted in increased “environmental and social responsibility of all sectors of society in the world.”<sup>24</sup> This big push for increased responsibility and awareness gave rise to environmental awards for achievements and certifications.

Numerous benefits may be possible for eco-certified businesses and buildings. Reduced operating costs, marketing advantages, local prosperity, customer attraction, increased public awareness, and of course, environmental support are all benefits that have been covered at length in many studies.<sup>25,26,27</sup> Researchers at James Cook University in Australia have also

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<sup>21</sup> CESD (2008)

<sup>22</sup> Geerts (2014)

<sup>23</sup> CESD (2008)

<sup>24</sup> Ibid

<sup>25</sup> Ibid

<sup>26</sup> Esparon, Gyuris, and Stoeckl (2014)

<sup>27</sup> Geerts (2014)

weighed in on the importance of certifications as they relate to customer perceptions of on-property environmental sustainability. In their findings, they remark that visitors at eco-certified accommodations perceived “better” performance from their operators than visitors at accommodations without an eco-certification.<sup>28</sup> When it comes specifically to third-party green building certifications such as LEED, additional unique benefits can be found for buildings, such as higher rental rates, resale values, appraisal values, occupant satisfaction, and recognition opportunities.<sup>29</sup>

Certifications come in many forms. Some are extremely difficult to obtain, others are completely voluntary and function on the honor system. Some certifications are available for free, other certifications require large fees, even just to apply. Some certifications require renewal and continued improvement check-ins with periodic audits, others are available for life. In the case of green building certifications, there is a wide spectrum of available certifications. All are good, but none are perfect, and the decision on whether or not to pursue one of the certifications will depend on a project’s location, budget, and mission.

Shown in the table in **Figure 5** is a comparison of five of the main green building certifications available, including LEED. Some of these are focused on the United States but are still available internationally. The five certifications systems shown in the table are LEED, which is run by the United States Green Building Council,<sup>30</sup> WELL Building Certification, which is run by the International Well Building Institute,<sup>31</sup> BREEAM (Building Research Establishment Environmental

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<sup>28</sup> Esparon, Gyuris, and Stoeckl (2014)

<sup>29</sup> Green Building Alliance (2017)

<sup>30</sup> USGBC, “About LEED” (2017)

<sup>31</sup> IWBI “Our Standard” (2017)

Assessment Method), which is run by the Building Research Establishment (BRE),<sup>32</sup> EnergyStar, which is run the United States Environmental Protection Agency,<sup>33</sup> and the Living Building Challenge, which is run by the Living Future Institute.<sup>34</sup>

|                   | Total Commercial Certifications | Multi-Criteria or Single Criterion? | Multiple Rating Levels? | Prescriptive or Performance-Based? | Requires Renewal? | Free? |
|-------------------|---------------------------------|-------------------------------------|-------------------------|------------------------------------|-------------------|-------|
| <b>LEED</b>       | 90,000                          | Multi-Criteria                      | Yes                     | Performance                        | No                | No    |
| <b>WELL</b>       | 350                             | Multi-Criteria                      | Yes                     | Both                               | No                | No    |
| <b>BREEAM</b>     | 561,000                         | Multi-Criteria                      | Yes                     | Prescriptive                       | Yes               | No    |
| <b>EnergyStar</b> | 30,419                          | Single-Criterion (Energy)           | No                      | Performance                        | Yes               | Yes   |
| <b>LBC</b>        | 41                              | Multi-Criteria                      | Yes                     | Both                               | No                | No    |

Figure 5: Green Building Certification Comparison (Company Websites, 2017)

This table is only meant to show a small number of available green building certifications. It is not intended to represent the “best” certifications or the most widely-used certifications. Additionally, there are more criteria to consider beyond the criteria shown in the table that may make these rating systems more similar or dissimilar. Some of those similarities or differences can be attributed to rating systems that have partnered with one another to make their criteria purposefully similar or synergistic to entice project teams to pursue both certifications.<sup>35</sup> Others act more as competitors in the green building certification space.<sup>36</sup>

<sup>32</sup> BRE “BREEAM” (2017)

<sup>33</sup> US EPA “Energy Star Certification” (2017)

<sup>34</sup> ILFI “Living Building Challenge” (2017)

<sup>35</sup> USGBC, “What is WELL?” (2017)

<sup>36</sup> Mark (2013)

Beyond purely green building certifications that are only concerned with a project’s physical structure and the resource consumption levels from the physical building’s perspective, hotels can also engage with certification systems that recognize operational sustainability as well. For example, TripAdvisor, a large global travel site that provides reviews of travel-related content, operators, and products, established the TripAdvisor GreenLeaders program in 2013 to



Figure 6: TripAdvisor GreenLeaders logo (TripAdvisor, 2017)

prominently display a ranking of sustainability on property listings throughout their site.<sup>37</sup> This program is meant to “[showcase]

a variety of eco-friendly hotels and B&Bs, from budget to luxury, [that are] committed to green practices like recycling, local and organic food, and electric car charging stations.”<sup>38</sup> According to the USGBC’s LEED in Motion report from 2016, an average GreenLeader hotel boasts a 20% higher rating on TripAdvisor.<sup>39</sup>

Additional certifications for hotels that are specific to hospitality and not necessarily tied to a website like TripAdvisor (where eco-certifications are a tangential attribute to the core purpose of the organization) include Green Key, Green Globe, Earth Check, Sustainability Tourism Eco-Certification, Ecotel, and additional criteria laid out by the Global Sustainable Tourism Council.<sup>40</sup>

Any certification will have its limitations, so context is the most important to understand when it comes time to choose which may be appropriate for a project. This importance of understanding

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<sup>37</sup> Green Traveler Guides (2017)

<sup>38</sup> TripAdvisor “GreenLeaders” (2017)

<sup>39</sup> USGBC “LEED in Motion: Hospitality (2016)

<sup>40</sup> Goldstein and Primlani, HVS (2012)

goes for a project team applying for certification as well as for anyone who lives or works inside a certified building. It is also important to consider the process for fairness and objectivity in the certification. Nondiscrimination, clearly defined criteria, impartial evaluation and certification decisions, unfettered participation, impartiality, objectivity, and established procedures for appeals, revocations, and revisions to standards are all important characteristics to look for in a well-made environmental certification system for hotels.<sup>41</sup>

Lastly, it's important to understand the difference between first-party certification, or self-evaluation, and third-party certification. Most of the well-known green building certification or sustainable hospitality certifications are third-party certifications, meaning a "neutral, independent third party evaluates the compliance of the product with clearly defined standards."<sup>42</sup> According to the Green Building Alliance, "third-party certification is a great way to add credibility to any green building."<sup>43</sup> Additionally, a third-party certification implies a certain level of integrity and transparency of data, as provides some level of accountability, and although third-party certification is not the only way to indicate the sustainability of green building, "it certainly is one of the most efficient way to guarantee you get [a healthy and high-performance space]."<sup>44</sup> Due to the more thorough certification process involved with third-party evaluation, researchers have reported that third-party certification programs can help mitigate the detrimental effects of "greenwashing" in the hotel industry, among others.<sup>45</sup> It can also play a

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<sup>41</sup> CESD (2008)

<sup>42</sup> Ibid

<sup>43</sup> Green Building Alliance (2017)

<sup>44</sup> Ibid

<sup>45</sup> Larceneux, Benoît-Moreau, and Parguel, (2011)

large role in helping hotels to establish themselves as “frontrunners” in their competitive set.<sup>46</sup> First-party certifications certainly have their place in the industry as well, but may require more thorough exploration on the part of guests and other hoteliers and more transparent explanation to understand what the hotel had to do in order to obtain that certification.

## **Overview of LEED Certification**

LEED stands for Leadership in Energy and Environmental Design and is a third-party prescriptive certification available for many building types through the United States Green Building Council (USGBC).<sup>47</sup> It focuses on sustainable construction and design and efficient resource consumption and energy use. While LEED generally targets new construction, there are opportunities for many kinds of projects to pursue LEED certification at any stage in a building’s life cycle. Certification can come from one of five separate rating systems:<sup>48</sup>

- LEED Building Design and Construction (BD+C)
- LEED for Interior Design and Construction (ID+C)
- LEED for Building Operations and Maintenance (O+M)
- LEED for Neighborhood Development (LEED ND)
- LEED Homes

Through these different systems, LEED acts as a decision-making framework for project teams throughout the cycle of development, which includes planning, design, construction, and operations. Developers can choose the rating system that best fits their project, as each rating

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<sup>46</sup> Black and Crabtree (2007)

<sup>47</sup> USGBC, “LEED – Better Buildings are our Legacy” (2017)

<sup>48</sup> USGBC, “About LEED” (2017)

systems comes with its own set of prerequisites and project opportunities to earn the credits necessary for a certain level of certification. LEED, in addition to being a certification scheme, is also a tool and guide for project teams, and has a goal of certifying buildings that not only complement the environment and enhance communities they call home, but also give people bright, healthy spaces in which to live, work, and play. Through its prescriptive framework, LEED offers clear guidelines on how the USGBC believes buildings can be sustainable.



*Figure 7: LEED logo (USGBC, 2017)*

LEED began in 2000 as a certification system for sustainable building and construction projects and helped to introduce the idea of the buildings as living environments with highly interconnected systems<sup>49</sup>. The goal was to bring architects, developers, materials specialists, engineers, designers, and others together to allow for a multidisciplinary and integrative process for building design and construction that

would not only lead to superior building performance, but also to environmental prosperity.<sup>50</sup>

LEED focuses on an integrative process for buildings that creates positive impacts for both the built environment and the natural environment. It accomplishes this through an emphasis on low resource use, indoor environmental quality, sustainable materials selection, and other

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<sup>49</sup> USGBC, "About LEED" (2017)

<sup>50</sup> Ibid

sustainability tactics.<sup>51</sup> Those themes are then organized and expanded on in various categories in LEED's scoring system.



Figure 8: LEED Certification Levels by Points (USGBC, 2017)

LEED Certification comes in four levels: Certified, Silver, Gold, and Platinum.<sup>52</sup> LEED certification evolved through various systems over time, and under LEED's most recent rating system, LEED v4, there are 110 possible points that a building can earn based on various credits that the building incorporates in the building process or in the building itself. These credit-earning opportunities include projects, systems, materials, and technology. Certain minimum requirements must be met in certain categories to achieve any level of LEED certification, and beyond that point, project teams can choose to pursue which credits they feel are most suitable to the goals of the building, their requirements for sustainability, and their budget. The point requirements for each category are shown in **Figure 8**.

LEED v4, which was introduced in November 2013, is LEED's most recent version of accreditation<sup>53</sup> and represents the USGBC's goal of staying flexible and staying relevant to the

<sup>51</sup> USGBC, "What is Green Building?" (2015)

<sup>52</sup> USGBC, "LEED – Better Buildings are our Legacy" (2017)

<sup>53</sup> Long (2014)

construction industry. The notable changes from LEED 2009 include the development of a web-based tool for data gathering and statistical analysis of performance, the creation of different scorecards for distinct building types and real estate projects under the same LEED certification system, and the introduction of “Impact Categories that focus on the social, environmental and economic goals of LEED and measure each strategy according to their ability to meet those goals.”<sup>54</sup> According to the USGBC, LEED 2009 asked the question, “How can LEED reduce environmental issues,” whereas LEED v4 asks, “What should a LEED project accomplish?”<sup>55</sup> There has been a notable shift to a system that is not only more customizable for the built environment and easier to use but is also more focused on the big-picture of sustainable development goals while still operating within the analytical, prescriptive framework of the previous version of the LEED certification system. The scorecard for LEED v4 is available in **Appendix B**. This is the most outcome-focused version of LEED that the USGBC has presented.

LEED v4 features six main credit categories:<sup>56</sup>

- Location and Transport
- Sustainable Sites
- Water Efficiency
- Energy and Atmosphere
- Materials and Resources
- Indoor Environmental Quality

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<sup>54</sup> Owens, Macken, Rohloff, Rosenberg (2017)

<sup>55</sup> Ibid

<sup>56</sup> USGBC, “About LEED” (2017)

Each credit category has a different number of credits available. There are also credits available for innovations that extend the sustainability of the building beyond what LEED requires, as well as credits for site selection practices and “regional priority” credits, which are meant to “incentivize the achievement of credits that address geographically specific environmental priorities.”<sup>57</sup> Regional priority credits began with LEED 2009 (version 3) and are available to any building by simply awarding extra points for certain other categories or projects on the regular LEED scorecard. A full point breakdown is shown **Appendix A**.

All of these credit categories are meant to be complementary to LEED v4’s new Impact Categories.

These Impact Categories come in the form of goals that LEED projects should pursue:

- Reverse Contribution to Global Climate Change
- Enhance Individual Human Health and Well-Being
- Protect and Restore Water Resources
- Protect, Enhance and Restore Biodiversity and Ecosystem Services
- Promote Sustainable and Regenerative Material Resources Cycles
- Build a Greener Economy
- Enhance Social Equity, Environmental Justice, and Community Quality of Life

The Impact Categories are designed to create a framework that will lead to “an ambitious agenda for the buildings industry” that will lead to more LEED certified projects “positioned to deliver a set of performance outcomes that cross-cut the Impact Categories in an integrated way.”<sup>58</sup>

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<sup>57</sup> USGBC, “What are Regional Priority (RP) Credits?” (2017)

<sup>58</sup> Owens, Macken, Rohloff, Rosenberg (2017)

Although broad categories, these cross-sections of impact understandings will help the building industry to view its effects on global challenges in a more direct way.

As of April 2017, the USGBC boasted more than 90,000 commercial projects across 165 countries and territories, with an additional 2.2 million square feet of certified space being added daily.<sup>59</sup> For more information on LEED hotels, both in the United States and throughout the world, please see **Appendices A-D, F-J**. Clearly, the reach of LEED is already impressive and has surely had immeasurable positive impacts on the green building industry. However, participation in LEED comes at a cost.

Despite the possible additional costs and possible doubts about economic benefits, which can vary from project to project and be subject to heavy discussion, project teams for many buildings, including hotels, have determined that LEED certification is a good thing to include in their project.

### **LEED Certification in Hotels**

As it relates to hotels, LEED is now more salient and approachable than ever, thanks to LEED v4. LEED v4 offers a set of criteria that are customized for the hospitality industry.<sup>60</sup> This new system recognizes the clear differences across the various types of real estate and reconciles those differences with modified and adapted criteria and scorecards. The gap between LEED certification's intense focus on the physical building and a hotel's focus on operations is now beginning to close. The USGBC states that "emphasis was placed on the hospitality industry's distinct food service and room occupancy requirements, which differ greatly from commercial

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<sup>59</sup> USGBC, "USGBC Statistics" (2017)

<sup>60</sup> USGBC "LEED v4" (2017)

building applications such as office space and retail,”<sup>61</sup> during the LEED v4 development phase. The next step for hotels is to increase uptake of this certification.

Unlike other common sustainability tactics found in hotels, LEED certification, along with other environmental sustainability or efficiency certifications, is not a unifying factor for hotel brands. This is the case both in the United States and throughout the world. Despite the collective power of a brand, there is little brand-wide or brand-driven activity for LEED certification. Greenhotelier.com, a leading site for innovations and trends in sustainable hotels that works under the International Tourism Partnership, posits that large hotels chains “have moved away from building their own hotels relying instead on project developers to construct properties for them.”<sup>62</sup> Therefore, they have little stake in whether a property is LEED certified or not. The one notable exception to this idea is the Element brand by Starwood Hotels and Resorts, where every property is required to obtain LEED certification.<sup>63</sup>

Marriott International has shown particular interest in LEED and is working with LEED to create a LEED Volume Program with a “pre-certified prototype” for their hotel development projects.<sup>64</sup> One can hope that this trend of high-volume, brand-driven LEED certification will continue. However, many hotel companies have instead turned to their own internally-developed green building and operations certification schemes instead of binding themselves to LEED for their hotels. IHG has the Green Engage program, Fairmont Hotels and Resorts has a Sustainable Design

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<sup>61</sup> USGBC “LEED in Motion: Hospitality” (2016)

<sup>62</sup> Green Hotelier (2011)

<sup>63</sup> Lee, Seoki, and Heo

<sup>64</sup> Green Hotelier (2011)

Policy, and Hilton Worldwide has LightStay,<sup>65</sup> all of which are intended to measure sustainable practices at their company's hotels and strive to improve environmental sustainability and minimize impact where possible.

Despite hotels being such important components of the built environment and having such a large carbon footprint as an industry,<sup>66</sup> and even though certain brands have internally-driven sustainability programs, it sometimes seems as though sustainability initiatives have been put on the figurative back burner by major industry stakeholders that are driving the industry's agenda. Many hotels will pursue initiatives that are the "low-hanging fruit" of sustainability, such as the installation of low-flow fixtures, implementation of linen reuse programs, or lighting retrofits for LED bulbs. Unfortunately, the physical building itself seems to be an afterthought for many hotels, given that out of the world's approximately 187,000 hotels fewer than 3000 have achieved some level of LEED certification – just over 1%. In the United States, the ratio is slightly worse, with approximately 300 LEED certified hotels out of about 50,000 total properties.<sup>67</sup>

An interesting element of LEED as it relates to hotel brands, especially in the United States, is the idea of LEED certification as a means of setting the tone of sustainability in a brand without needing to pursue it at each property. This is exemplified by the fact that many hotel companies choose to have corporate headquarters or office buildings that are LEED certified, even if only a few of their properties have some level of LEED Certification. The Marriott Headquarters building in Bethesda, Maryland received a LEED Gold certification in 2012.<sup>68</sup> Starwood Hotels' corporate

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<sup>65</sup> Green Hotelier (2011)

<sup>66</sup> GRESB, 2016

<sup>67</sup> USGBC Public LEED Project Directory (2017)

<sup>68</sup> Ibid

headquarters, One StarPoint, in Connecticut was certified as LEED Platinum and their corporate office in Scottsdale, Arizona received LEED Certified status in the same year.<sup>69</sup> Hilton relocated their corporate headquarters even earlier, moving into their current LEED Gold certified building in Virginia in 2010. Hyatt’s LEED Platinum headquarters and Wyndham’s LEED Silver buildings were also part of the early-movers group in 2010. Wyndham’s headquarters has since improved to LEED Gold status.<sup>70</sup>

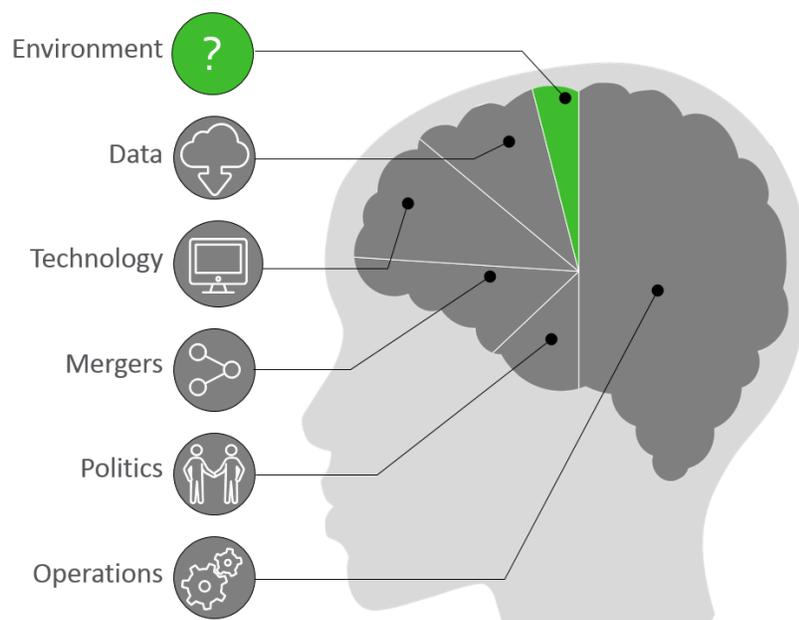


Figure 9: The Mind and Prioritizations of a Hotelier (custom graphic, 2017)

As the old adage goes, “you can’t manage what you can’t measure.” In fact, independent global environmental and social governance research firm Responsible Research noted how a hotel company that simply “outlines specific goals and targets to be achieved over set timelines” is already taking

big steps toward smart, sustainable policy.<sup>71</sup> Hoteliers have to juggle a lot of complex elements in order to provide their guests with great service, and at any given time, are thinking about hundreds of small thoughts, ideas, or issues. In order to be successful, hoteliers have to keep a

<sup>69</sup> USGBC Public LEED Project Directory (2017)

<sup>70</sup> Ibid

<sup>71</sup> Blinch et al (2011)

finger on the pulse of many distinct parts of society. However, the environment cannot be forgotten. Could LEED certification be an answer to ensure that the environment remains a piece of the mind of a hotelier, even if a small one? That way, environmental sustainability can be an inherent part of everything that they do, instead of just an afterthought.

LEED certification could be more prominent in the hotel industry if hotel owners and operators had a better understanding of the consequences of LEED certification, both good and bad, and understood how to implement sustainability initiatives at their properties in an effective way. This study hopes to contribute to that discussion and shed light on the effective and ineffective elements of LEED as it relates to the hotel industry and individual hotel performance.

## LITERATURE REVIEW

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A lot of literature is available that discusses the impact of environmental sustainability on hotels, the impact of environmental certifications on businesses, the impact of LEED certification on real estate performance, the overlaps in green building methods and hotel construction and design, and other slightly broader relationships that accompany some big ideas with hotel sustainability. However, a gap currently exists for academic research that specifically examines the relationship that LEED certification has with hotels and how that relates to their levels of environmental sustainability (and tangentially, their expenses, guest experience ratings, employee satisfaction, etc.). Some research exists, but this paper hopes to either extend or dig in further on the existing literature. At the very least, an examination of this specific relationship will add to the discussion in the industry.

### **Evaluating a Hotel's Decision to Pursue LEED Certification**

One of the first things to consider as a hotel looking at LEED certification is simply the cost of the certification itself. LEED, unlike certain other green building certifications, is not free. Both the certification itself and the process of obtaining it cost money. That said, there is no firm consensus on the exact costs of LEED certification. The financial implications of LEED certification in a hotel are a hot topic for debate, and some research has portrayed LEED as a clear ROI opportunity, while other scholars are more cautious in their support of eco-certification schemes like LEED, or even against them entirely. A commonly cited cost comparison study done by engineering company Morrison Hershfield showed that LEED certified buildings generally require a 0.08% cost premium to construct, 3.5% for Silver, 4.5% for Gold, and 11.5% for Platinum,

although theoretically there would be no limit to the construction premium on LEED Platinum buildings,<sup>72</sup> especially on the new LEED v4 System. However, as Nora Knox of the USGBC notes, “the public dramatically overestimates the marginal cost of green building,”<sup>73</sup> an idea that is supported by a 2007 public opinion survey on green building done by the World Business Council for Sustainable Development, in which respondents estimated green building to be a 17% cost premium, when in reality, it was closer to 2%.<sup>74</sup> While at first these claims may seem impossible, another landmark study on the premium in construction costs of LEED buildings by Davis Langdon found that “there is no significant difference in average costs for green buildings as compared to non-green buildings.”<sup>75</sup> Gregory Kats proposed that additional costs may exist, but not necessarily due to the cost of materials or labor expertise. Instead, they are primarily due to “increased architectural and engineering design time, modeling costs and time necessary to integrate sustainable building practices into projects,” all of which can be mitigated with appropriate planning far in advance of the start of the design and construction phase of a building.<sup>76</sup> A slightly more recent study done in 2012 of 160 LEED certified buildings showed that LEED buildings were met with a cost premium ranging from 2.9% to 9.4%, with a mean of 4.1%. It also found that a building could offset those costs and see a return on the investment in green building with LEED certification since those buildings had \$0.70/sqft lower operating costs than their non-LEED counterparts, as well as 31% lower energy costs.<sup>77</sup>

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<sup>72</sup> Barbieri (2008)

<sup>73</sup> Knox, 2015

<sup>74</sup> Kats (2003)

<sup>75</sup> Langdon (2007)

<sup>76</sup> Kats (2003)

<sup>77</sup> Nyikos, Thal, Hicks, and Leach (2012)

On the subject of energy costs, energy use in LEED buildings specifically has been a contentious area for researchers. In 2009, Newsham et al claimed in a study that LEED certification in buildings led to 18%-39% energy cost savings.<sup>78</sup> A competing study analyzed their findings and disputed them directly, demonstrating that errors in calculations actually made the results of the study inconclusive.<sup>79</sup> A conclusive result would be very important in determining the utility of LEED certification both from an environmental standpoint as well as a financial one since energy can be a large part of a hotel's overall utility bill.

In addition to the increased costs of construction, LEED certification itself comes with a cost. There is a flat fee of \$1,500 that project teams must pay to register a project with LEED, and then a flat \$5,000 pre-certification fee. From there, different levels of certification processes can cost different amounts depending on the size and complexity of the building at hand. For the entire LEED process, large buildings may pay upward of \$50,000.<sup>80</sup> For any building, expedited processes and appeals also come with fees. However, members of the USGBC at the Silver, Gold, or Platinum level enjoy slightly reduced fees.<sup>81</sup>

The costs of green building under the framework of LEED can best be summarized as present but minimal, even though not all current research agrees. However, even though these green buildings may cost more, many developers find that these increased up-front costs are made up over time from reduced operating costs and other financial benefits. LEED, in effect, becomes a guide for an ROI opportunity rather than a simple certification program.

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<sup>78</sup> Newsham, Mancini, and Birt (2009)

<sup>79</sup> Scofield (2009)

<sup>80</sup> USGBC, "LEED Certification Fees" (2017)

<sup>81</sup> Ibid

In a study of 10,000 buildings, Eichholtz, Kok, and Quigley highlight four distinct ways in which green building can lead to economic benefits for the building's project team: energy efficiency, indoor environmental quality, corporate reputation boosts for tenants (making the building a more desirable location), and lengthened economic lifespan of the building.<sup>82</sup> A recent CoStar report on the Los Angeles rental market found that tenants in LEED certified spaces would be willing to pay \$2.91/sqft compared to \$2.16/sqft for non-LEED space.<sup>83</sup> However, these are mainly focused on office and residential buildings and their tenants, and may not necessarily translate to a hotel, where the "lease terms" go from being year-to-year to night-by-night.

According to the McGraw Hill Construction's World Green Building Trends Report, a partner of the USGBC, operating costs for newly constructed LEED certified buildings decreased by 15% over five years, building value increased by 7%, and asset value increased by 5%. For existing buildings undergoing green retrofits, the statistics were equally compelling – a 13% decrease in operating costs over five years, 5% increase in building value, and 4% increase in asset value. Overall, new construction of LEED buildings saw an 8-year payback period, and existing buildings were targeting a 7-year payback period.<sup>84</sup>

The benefits don't just stop at decreased operating costs and opportunities for increased revenue from sustainability. There are also certain indirect benefits that can be financially and socially beneficially for LEED properties. The USGBC states that structural incentives such as expedited review processes and financial incentives like tax credits and waived fees for developers are

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<sup>82</sup> Eichholtz, Kok, and Quigley (2010)

<sup>83</sup> Los Angeles Better Buildings Challenge (2014)

<sup>84</sup> McGraw Hill Construction (2013)

common from municipalities or other levels of government. Governments have also been known to offer technical assistance and marketing support for green buildings in some areas because they believe that rewarding green building practices “spurs innovation and demand for green building technologies,”<sup>85</sup> which for many areas, is a priority. These are clear benefits that a building without a LEED certification, regardless of its level of sustainability, would have a very difficult time obtaining. Each governmental entity will treat LEED certification differently and reward LEED-focused developers in different ways. However, in the United States, some state governments do not allow the use of LEED because of issues with its certification criteria. These relationships are elucidated in **Appendix D**. Other indirect financial benefits of LEED buildings may include increased worker productivity and engagement,<sup>86</sup> as well as increased customer retention from positive public relations.<sup>87</sup>

While it may be assumed that a hotel should pursue the highest certification level, it is not that simple. While some credits are relatively inexpensive to obtain, or possibly even free depending on pre-construction elements like site selection and regional geography, other projects can cost several hundred thousand dollars or more just to obtain one credit. A hotel wants to minimize the cost of going green while still helping make a tangible, beneficial impact on the environment. According to Michael Spencer, this paves the way for an interesting optimization problem.

Michael Spencer created a design tool called the ASPEN tool that is a LEED credit design tool as well as a LEED cost minimization tool.<sup>88</sup> His tool applies linear programming methods to the

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<sup>85</sup> USGBC, “Good to Know: Green Building Incentive Strategies” (2014)

<sup>86</sup> Chapla (2012)

<sup>87</sup> McGraw Hill Construction (2011)

<sup>88</sup> Spencer (2012)

various project costs on the LEED scorecard and helps hotels decide which projects to target and how they should correspondingly adjust their LEED certification goals. In simple terms, the objective function is to minimize the cost of the project, subject to a number of credits that grant the distinct levels of LEED certification. Variables include every credit associated with every option (such as installing an HVAC system for the Thermal Comfort credit) in every category (such as Indoor Environmental Air Quality). Additional breakdown of credit categories is available in **Appendices A-B**. A summary of the linear programming model is available in **Appendix E**.

The users of the ASPEN tool select either one of the four available ratings (Certified, Silver, Gold, and Platinum) or an “undefined” certification, which allows a hotel property to run the calculation without a rating boundary so that they can select their own credit opportunities and decide on which LEED certification level to pursue. Because of this, it lacks a binding rating objective and will not minimize the costs of the selected credits. It can, however, still produce the cost and rating associated with the chosen credits and let the user know how much more they would need to receive a higher rating while ensuring they still complete the minimum LEED checklist for a rating. If a rating is selected, however, the optimization calculation is bound to the minimum and maximum credits needed to achieve the desired rating.<sup>89</sup>

The integer programming function must solve for the cost minimization objective and select the optimal credits within the rating boundary. This tool can be extremely beneficial for hotels looking for a way to take responsibility without dipping too far into their finances. It enables them to run efficiently and obtain useful certification without breaking the budget.

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<sup>89</sup> Spencer (2012)

All of this variation in costs, benefits, and certification level may be too “noisy” to truly understand the picture of LEED. In a case study of six buildings, researchers at Czech Technical University in Prague examined only the required elements of LEED certification, with particular attention given to water and energy, as a means of isolating the effects of LEED’s mandatory requirements. Specifically, they used their research to express that a LEED certified building should be achieving 10% reduced energy use and 20% reduced water use from minimum LEED certification requirements.<sup>90</sup> Building owners who decided to have their buildings LEED certified were able to generate operational savings. However, they also found that “there are very few enlightened building owners who have realized this importance of the operational expenditures and most are not willing to risk the immediate financial effectiveness of the project by increasing the capital cost to allow for more efficient equipment, etc.”<sup>91</sup>

Again, it is generally agreed upon that the costs of LEED are not negligible, but are also not overly burdensome. From a physical building operations standpoint, there are ROI opportunities that accompany LEED certification due to expense reductions across various categories. Hotels also see the possibility to increase revenue.

### **The Impact of LEED Certification on Hotel Revenue**

Hotels should choose to participate in LEED certification, not only to take responsibility for the role they play in the environment but also because it can benefit them financially. Numerous studies have examined the impact of LEED certification on hotel financial performance with

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<sup>90</sup> Dobias and Macek (2014)

<sup>91</sup> Ibid

different methods for examining various metrics. Some results have been more optimistic than others.

Although not specific to LEED, a study run at Cornell University that compared the booking revenue activity of 3000 “green” hotels, as marked by Travelocity’s website, to 6000 “non-green” hotels found that, on average, “booking revenue neither increased nor decreased for the certified hotels.”<sup>92</sup> Their findings, which show that “earning a green certification does not automatically result in a large revenue bump nor a revenue fall,” brought them to their conclusion of shining a “cautious green light” for hotel eco-certifications, including LEED.<sup>93</sup>

A study conducted in 2014, also at Cornell University, focused on the comparison of 93 LEED certified hotels’ financial performances over a period of time relative to a statistically similar set of 514 non-LEED hotels. This study was of particular importance because it is one of the few studies available that examines the same batch of hotels pre- and post- certification instead of using a method that requires the creation of comparable sets of hotels, some that are LEED and some that are non-LEED, but as a group are overall relatively similar and therefore reasonable to compare on an aggregate level. They found a general trend toward superior financial performance for hotels after achieving LEED certification.<sup>94</sup> Before certification, the hotels had been underperforming compared to other hotels in the industry. However, after certification, LEED certified hotels saw a big boost in revenue per available room (RevPAR), which was driven by jumps in average daily rate (ADR), because the study also saw lower occupancy rates post-

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<sup>92</sup> Chong and Verma (2013)

<sup>93</sup> Ibid

<sup>94</sup> Walsman, Verma, and Muthulingam (2014)

certification.<sup>95</sup> This helped these hotels to surpass the competition. Within the first year after certification, they were earning \$115 in revenue per available room compared to their competitive set which was earning \$106 in revenue per available room. Despite experiencing lower occupancy rates than their competitive set, going from 63% occupancy to 66% occupancy and then dropping back down slightly, in comparison to their competitors, who were operating at 67% occupancy and were slowly increasing toward 70% occupancy, hotels still improved their profitability after LEED certification when examining the RevPAR metrics.<sup>96</sup> The study overall shows that LEED hotels in the United States outperform their non-certified competitors in the industry's common revenue benchmarking metrics. This should help encourage non-certified hotels to pursue LEED certification.

When examining this study in relation to the 2013 study of Travelocity-flagged "green" hotels that did not find any significant rise or fall in revenue for eco-certified hotels, a logical conclusion may be that LEED, more so than other certifications, is a driver of increased profitability in hotels. The earlier study included certifications like EnergyStar, which may have actually been bringing the average down. When the effect of LEED became isolated in the later study in 2014 by Walsman et al, it was more evident that it was tied to revenue increases for individual hotels.

Despite these highly provocative findings, the study still noted a few opportunities to fill gaps that it had left. For example, this study only focused on revenue, but more research would need

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<sup>95</sup> Walsman, Verma, and Muthulingam (2014)

<sup>96</sup> Ibid

to be done to understand the effect that LEED certification can have on a hotel's overall profitability. Much of that profitability relies on expense savings from LEED.

A 2016 study was able to use a larger sample size in an analysis of LEED certification alongside EnergyStar certification in hotels. A sample of 259 eco-labeled hotels (LEED or EnergyStar) were examined against a comparable set of 1272 hotels. They again found that LEED gave a statistically significant boost to ADR but a decrease in occupancy rate. Still, when examining RevPAR, which is a combination of ADR and occupancy, they saw a negligible difference between their LEED and non-LEED set, unlike the Walsman et al study which concluded that the rise in ADR was enough to offset the decrease in occupancy, and therefore give a meaningful boost to overall RevPAR at a property.<sup>97</sup> EnergyStar, on the other hand, saw the opposite effect, with an increase in occupancy but a decrease in rate, which still yielded a neutral RevPAR.<sup>98</sup>

One area where there exists a gap in academic research is the idea that LEED hotels tend to be newer and more aesthetically pleasing, which could have clear effects on their profitability that have nothing to do with their LEED certification status. LEED didn't enter the industry until the 21<sup>st</sup> century, but there are many hotels in the industry that were constructed in the 1900s, or even in the 1800s. Older buildings might require more CapEx spending or have higher utility costs due to lower efficiency, simply because efficient building technology was not available at the time of their construction, but today it is ubiquitous in the construction industry. LEED buildings, due to the requirements for natural light, ventilation, vegetation, and other areas of the LEED scorecard also may simply be nicer looking buildings, and therefore more attractive to guests and

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<sup>97</sup> Robinson and Das (2016)

<sup>98</sup> Ibid

local events, which would also artificially drive revenue for LEED certified buildings and skew results. LEED certification's effects should, as best as possible, be contained just to the nature of sustainability at a property when they are being examined, and side-effects of LEED certification like aesthetics or "newness" should be left out of the equation.

### **The Impact of LEED Certification on Guest Satisfaction**

One element of hotel financial performance that cannot be overlooked is the relationship that it shares with guest satisfaction. Some exploration of LEED's impact on guest experience has been done and is a useful contribution to the discussion of LEED certification in the hotel industry.

The hotel industry is not inherently associated with sustainability. Therefore, guests don't always expect to encounter the various sustainability measures that hotels are increasingly implementing. However, sometimes sustainability measures can be viewed as ancillary services that together provide benefits to guests, even if those benefits are not entirely tangible.<sup>99</sup> When it comes to the possibility of the "cost" of those sustainability measures from the guests' point of view, studies show that customers' willingness to pay for sustainability in a hotel is highly correlated with their general level of concern for the environment.<sup>100</sup> However, this still may make some hoteliers nervous given that there is no guarantee that a guest at their property will care at all about the environment or share the same values as a hotel's manager or brand that is pushing sustainability, which could lead to dissatisfaction, decreased repeat stays, and generally detrimental effects on a hotel's revenue.

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<sup>99</sup> Manaktola and Jauhiri (2007)

<sup>100</sup> Kang, Stein, Heo, and Lee (2012)

Careful marketing plans at hotels can help to reverse any detrimental effects of guests who see sustainability elements and associate them with an increased cost of their stay. Little has been done to connect LEED certification specifically to improved hotel ratings from guests. However, one study examined the impacts of ISO 14001 certification on hotel guest reviews, and found that “certification may give upscale hotels a distinctive asset that leads them to a competitive advantage over similar non-certified properties.”<sup>101</sup> It is possible that a similar idea could be extrapolated to LEED certification, but more research would be necessary to draw that conclusion.

### **LEED Certification’s Managerial Implications for Hotel Operations**

LEED certification carries weight in a hotel before, during and after a property is LEED certified. There are many important elements of management for hoteliers to consider to ensure that a property is truly as sustainable as its LEED certification would imply.

Staff training is a major element of hotel sustainability. If a property is LEED certified, then the staff at that location should know and understand what that means, and how they can incorporate sustainability into their individual job functions, even if only in a small way. Use of incentive programs has been noted as effective for accomplishing goals like employees recycling, water saving, and even taking public transportation to and from work.<sup>102</sup> One key area for hotels to consider is the rooms department. Housekeeping should be “a particular target since employees have significant opportunities to influence the economic use of resources and

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<sup>101</sup> Segarra-Oña et al (2014)

<sup>102</sup> Hsiao, Chuang, Kuo, and Yu (2014)

materials (e.g., electricity, paper, and water)” which is why “many green hotels encourage employees to adopt green housekeeping practices” in everything they do on-property.<sup>103</sup>

Hotel management teams are key components of a hotel’s sustainability, and therefore, LEED certification comes with important implications for the leadership at any property and within any department. Managers sometimes criticize the ambiguity and confusion that surrounds certain eco-certification schemes for hotels, including LEED, and cite that confusion as a reason why additional action beyond the certification is difficult.<sup>104</sup> However, the onus is on those managers to spearhead initiatives that leverage the already in-place base level of sustainability that LEED certification brings to a hotel. They have an obligation to carry through with a certification, especially because the extent to which an on-property leadership team is aware of the specifics of an environmental certification like LEED will affect their ability to make sound judgments on environmental management and sustainability innovation.<sup>105</sup>

Overall, a hotel shouldn’t obtain LEED certification and then simply consider themselves done with sustainability at the property. LEED must be the catalyst for a way of doing business that respects the environment and not a stopping point for sustainability efforts. The certification should represent more than just evidence of a well-designed physical structure. It should represent a commitment to responsible business tactics.

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<sup>103</sup> Hsiao, Chuang, Kuo, and Yu (2014)

<sup>104</sup> Geerts (2014).

<sup>105</sup> Hsiao, Chuang, Kuo, and Yu (2014)

## Criticisms of LEED Certification

Although there is little formal academic research on this topic, an important element of this paper is understanding the criticisms and possible shortcomings of LEED certification for hotels, and in general as a green building certification. These extend beyond the idea of costs and returns on investment, and instead function more as criticisms of elements that are inherent to the core philosophical repercussions of what LEED prioritizes in buildings.

One of the main criticisms of LEED, as it relates to hotels, is that LEED does not capture all of the operational complexity in hotels that makes hotels so unique. Hotels are far more than just physical structures. Randy Durband, CEO of the Global Sustainable Tourism Council, points out that “LEED covers the building, how green is it, how good is the insulation, how sustainable is the built-in energy source system – purely physical stuff. It doesn’t speak to [the sustainable] process.”<sup>106</sup> This focus on the physical building is fine if hotels choose to pursue this, but this also means that a LEED hotel might not even have, for example, recycling bins at the property. A hotel isn’t necessarily operated sustainably just because its operations take place inside of a sustainably-built shell.

LEED has also received some backlash for its status as a prescriptive certification. Other green building certifications require the building to keep up their performance, or sometimes even improve over time. This is checked with audits and transparent reporting. With LEED, however, the relationship between the USGBC and the project is cut off as soon as certification is awarded. There is no evaluative element to LEED. As the Center for Ecotourism and Sustainable

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<sup>106</sup> Wood (2016)

Development reports, a well-designed certification is one that “requires re-application after a given time period, to protect against greenwashing.”<sup>107</sup> This could not be truer. LEED buildings that have been certified for a number of years have the very real possibility of no longer being deserving of a LEED certification – additional reporting and auditing would be required.

Lastly, there may be a misalignment of the timeline for architectural design, hotel development, and physical construction of hotels and the timeline that LEED seems to have in mind for new construction projects. This idea is demonstrated visually in **Figure 10**. Management of the design process is crucial for the success and affordability of a LEED project, but it is difficult to align that with natural architectural progression in a project.<sup>108</sup>

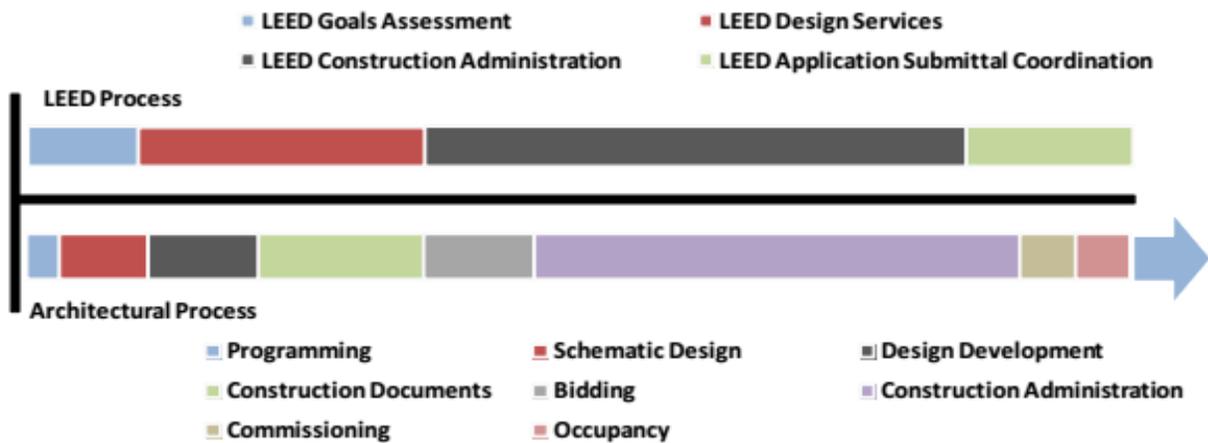


Figure 10: Misalignment of timelines for LEED Planning and Architectural Process (Spencer, 2012)

It is possible that there exists a misalignment or disconnect between the needs of the hotel industry regarding sustainability motivation and innovation and the requirements of LEED certification for the hotel’s design and construction phase or retrofit process for existing buildings. LEED is very building-focused, but when it comes to hotels, sustainability begins with people.

<sup>107</sup> CESB (2008)

<sup>108</sup> Spencer (2012).

# RESEARCH METHODS

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## Data Breakdown

Of 288 LEED certified US hotels (at any level of LEED Certification) identified in the Public LEED Project Directory from the USGBC, 87 records were matched to hotels in the Cornell Hospitality Sustainability Benchmarking Tool (CHSB) database. Of those 87 LEED hotels with CHSB records, 62 had verified data available for the years being examined (2014 and 2015). The data for 2015 was far more complete, so that year was the priority for this project's analysis. From the CHSB database, each of those 62 hotels, along with an additional 2224 properties that were provided for analysis, came with the following data attributes from the CHSB study:

- Metro Area ID
- Room Count
- Floor Area (m<sup>2</sup>)
- Rooms Floor Ratio
- Rooms Occupied
- STR Segment
- Asset Class (Service Type)
- Köppen–Geiger climate zone
- Laundry Included (Y/N)
- Monthly Average Temperature for Local Area
- Relative Humidity for Local Area
- Cooling Degree Days and Heating Degree Days
- Water & Energy Consumption, Carbon Footprint, all per Sq. M and per Occupied Room

**Figure 11** on the following page provides a full summary of the data composition for this study.

| 2015 Data Composition              |             |           |             |               |               |
|------------------------------------|-------------|-----------|-------------|---------------|---------------|
| Variable                           | Full Sample | LEED      | Non-LEED    | LEED %        | Non-LEED %    |
| <b>Sample Size</b>                 | <b>2286</b> | <b>62</b> | <b>2224</b> | <b>100.0%</b> | <b>100.0%</b> |
| <b>Full Service</b>                | 610         | 25        | 585         | 40.3%         | 26.3%         |
| <b>Limited Service</b>             | 1585        | 33        | 1552        | 53.2%         | 69.8%         |
| <b>Other</b>                       | 13          | 0         | 13          | 0.0%          | 0.6%          |
| <b>Luxury</b>                      | 126         | 9         | 117         | 14.5%         | 5.3%          |
| <b>Upper Upscale</b>               | 494         | 16        | 478         | 25.8%         | 21.5%         |
| <b>Upscale</b>                     | 834         | 30        | 804         | 48.4%         | 36.2%         |
| <b>Upper Midscale</b>              | 670         | 6         | 664         | 9.7%          | 29.9%         |
| <b>Midscale</b>                    | 87          | 0         | 87          | 0.0%          | 3.9%          |
| <b>Economy</b>                     | 1           | 0         | 1           | 0.0%          | 0.0%          |
| <b>5 Stars</b>                     | 53          | 4         | 49          | 6.5%          | 2.2%          |
| <b>4 Stars</b>                     | 340         | 14        | 326         | 22.6%         | 14.7%         |
| <b>3 Stars</b>                     | 1303        | 38        | 1265        | 61.3%         | 56.9%         |
| <b>2 Stars</b>                     | 513         | 3         | 510         | 4.8%          | 22.9%         |
| <b>Tropical</b>                    | 76          | 1         | 75          | 1.6%          | 3.4%          |
| <b>Arid</b>                        | 178         | 8         | 170         | 12.9%         | 7.6%          |
| <b>Temperate</b>                   | 1724        | 47        | 1677        | 75.8%         | 75.4%         |
| <b>Cold</b>                        | 308         | 6         | 302         | 9.7%          | 13.6%         |
| <b>In-House Laundry</b>            | 1735        | 39        | 1696        | 62.9%         | 76.3%         |
| <b>Out-Of-House Laundry</b>        | 378         | 14        | 364         | 22.6%         | 16.4%         |
| <b>Extra-Large (# Rooms)</b>       | 564         | 20        | 544         | 32.3%         | 24.5%         |
| <b>Large Room (# Rooms)</b>        | 562         | 18        | 544         | 29.0%         | 24.5%         |
| <b>Medium (# Rooms)</b>            | 564         | 19        | 545         | 30.6%         | 24.5%         |
| <b>Small (# Rooms)</b>             | 575         | 4         | 571         | 6.5%          | 25.7%         |
| <b>Extra-Large (m<sup>2</sup>)</b> | 560         | 22        | 538         | 35.5%         | 24.2%         |
| <b>Large (m<sup>2</sup>)</b>       | 438         | 17        | 421         | 27.4%         | 18.9%         |
| <b>Medium (m<sup>2</sup>)</b>      | 531         | 14        | 517         | 22.6%         | 23.2%         |
| <b>Small (m<sup>2</sup>)</b>       | 719         | 9         | 710         | 14.5%         | 31.9%         |

Figure 11: 2015 Data Composition for LEED vs Non-LEED Analysis

These 87 hotels with records in the CHSB study represent more than 30% of the total population of US LEED certified hotels. As is shown in **Appendix F**, the geographic distribution of these 87 records is geographically similar to the distribution of the full population LEED certified hotels in the United States.

For additional insight on US LEED certified hotels, please see **Appendices A-D & F-J**.

During the analysis, the LEED and non-LEED sets were generally chosen randomly, but some variables were filtered and sorted to obtain a better “apples to apples” comparison between the two sets.

## **Analysis Method**

Each CHSB record comes with the following metrics on sustainability and resource consumption. These values are self-reported by each hotel in the CHSB tool. They were verified and collected by Eric Ricaurte of Greenview, who oversees the study, and then anonymized, combined with LEED data, and shared for analysis in this study.

- Hotel Carbon Measurement Initiative (HCMI) value per occupied room
- Carbon Footprint per available room (room count) in kgCO<sub>2</sub>e
- Carbon Footprint per occupied room in kgCO<sub>2</sub>e
- Carbon Footprint per sq. meter in kgCO<sub>2</sub>e
- Energy Consumption per occupied room in kWh
- Energy Consumption per sq. meter in kWh.
- Water Consumption per occupied room in L
- Water Consumption per sq. meter in L

**Appendix K** provides full descriptive statistics for each of these metrics based on each variable in the CHSB study for all records for analysis.

Beginning with overall averages (mean) of the entire sample of data and then breaking down the data by grouping different hotels together by qualitative variable categories like chain scale or geography, the data were examined and analyzed mainly by comparing average consumption rates (for water and energy) or emissions (for carbon) in LEED hotel sets versus non-LEED hotel sets.

Single linear regression, multiple linear regression, and logistic regression were all attempted to quantify the statistical significance of the findings, but these tests were slightly ineffective simply due to the extreme heterogeneity of the data, as is generally inherent in property-level hotel data when drilling down to metrics as granular as utility consumption. These tests were also rendered less effective by the small sample size of LEED certified hotels.

## **Limitations**

This study has several limitations. One of the main limitations experienced during data collection and analysis was sample size. The usefulness, accuracy, or relevance of these findings may be called into question due to small sample size. That said, despite the objectively small sample size of 62 LEED certified hotels, that sample still represents nearly one-quarter of the entire population of US LEED certified hotels. There are not many LEED certified hotels in the United States, and most are completely anonymous with confidential data, so obtaining sufficient data for the study was difficult. More data may have improved results or made them more statistically significant, but overall, this level of data is enough to provide interesting insights and point to

noteworthy areas for future research and further examination. One last note on the sample size is that to maximize the sample size, no distinctions were made for LEED buildings that were new construction under LEED guidelines or existing buildings that converted and renovated to obtain LEED certification.

Regarding the CHSB data and the metrics it provides, there are also limitations. First, not all LEED hotels respond to the CHSB survey, so unless a LEED hotel was both identified in the USGBC Public LEED project directory and located in the CHSB database for 2015, it was not used in the study. Even fewer records were available for the 2014 data, which is why 2015 was the priority for analysis.

Second, all of the metrics are self-reported by the hotels, so there may be a slight variance from different measurement styles or human error, despite the thorough attempts by the CHSB tool to standardize and quality-check the data input process.

Regarding energy usage, occupancy based metrics are not the best metrics to use since much of the facility can be outside the guestrooms and not dependent on a hotel's occupancy, such as meeting space utilization, restaurants, or spas, which may have occupancy as a secondary driver for their usage. Therefore they would still be related to occupied rooms, but it would be minor. Additionally, the range of non-room floor area in the sample size exhibits a lot of variance. Occupancy is at best a good variable to insert and help in regression, but floor area is consistently the best metric to use to benchmark energy. For water, the case is different since water usage is heavily tied to guests, but if a hotel has a pool, restaurant, wet spa, gym or another amenity, a proper analysis can be challenging. One way to control for these differences might be to only

examine water and energy in limited-service properties which will have similar uses due to their general lack of additional amenities and non-room floor space allocations.

Carbon footprint metrics are also difficult to compare from hotel to hotel because they have another variable layered into their value: the emission factor to convert electricity to CO<sub>2</sub>, which varies across the US. From one region to the next, it can vary by a factor of up to 4x. Furthermore, carbon footprint has no relation to climate zone. This makes carbon footprint metrics extremely difficult to compare without grouping the data down to a point where, with this data set in particular, the grouping would become far too small.

Also, regarding the CHSB data, not every hotel provided data for every variable or sustainability metric, including both LEED and non-LEED properties. This is why **Figure 11** showed 2286 hotels as the total CHSB sample size, but some categories do not total to 2286. It can be assumed that the difference between the total sample size and the category subtotal is the number of properties with missing data since no data was eliminated deliberately from the sample.

Lastly, there is an extreme amount of heterogeneity in the data. This heterogeneity makes it difficult to say with certainty whether variance between LEED and non-LEED properties is truly due to LEED certification's effects, or whether it is inherent in the hotel industry given how each property, even with properties in similar geographies and similar brands with heavy amounts of property-level standardization strategies in place, is a unique property that will not be exactly like any other hotel in the world. This makes it difficult to find ways of comparing the data at hand with "twin" data sets and statistically similar groupings.

# DATA ANALYSIS

## Broad Results Output

| 2015   |        |                    |            |
|--|--------|--------------------|------------|
| Metric   | Value  | Unit               | Difference |
| <b>Average of HCMI Footprint per Occupied Room</b>           |        |                    |            |
| No   | 21.8   | HCMI metric        | 10.3%      |
| Yes  | 24.1   |                    |            |
| <b>Average of Total Carbon Footprint / # of Rooms</b>        |        |                    |            |
| No   | 6651.2 | kgCO <sub>2e</sub> | 13.2%      |
| Yes  | 7532.4 |                    |            |
| <b>Average of Total Carbon Footprint per OCRM</b>            |        |                    |            |
| No   | 25.1   | kgCO <sub>2e</sub> | 15.4%      |
| Yes  | 28.9   |                    |            |
| <b>Average of Total Carbon Footprint per Floor Area Sq.M</b> |        |                    |            |
| No   | 100.2  | kgCO <sub>2e</sub> | -2.4%      |
| Yes  | 97.8   |                    |            |
| <b>Average of Total Energy Use per OCRM</b>                  |        |                    |            |
| No   | 76.6   | kWh                | 14.6%      |
| Yes  | 87.9   |                    |            |
| <b>Average of Total Energy Use per Floor Area Sq.M</b>       |        |                    |            |
| No   | 300.4  | kWh                | -2.6%      |
| Yes  | 292.7  |                    |            |
| <b>Average of Total Water Use per OCRM</b>                   |        |                    |            |
| No   | 575.5  | L                  | 1.6%       |
| Yes  | 584.5  |                    |            |
| <b>Average of Total Water Use per Floor Area Sq.M</b>        |        |                    |            |
| No   | 2442.6 | L                  | -16.4%     |
| Yes  | 2041.4 |                    |            |

*Figure 12: Comparison of all means for full sample of CSHB data, LEED vs non-LEED*

Overall, although most of these findings are not statistically significant, the data shows that LEED performs worse for all metrics taken on a per occupied room basis and better for any metrics taken on a per square meter basis. Total room count, which, like square meters, is more a measure of size than it is of operations, is a possible exception, because LEED hotels were the “loser” when it came to this metric as well.

On a per square meter basis, LEED buildings are generally less resource intense. However, on a guest by guest basis or a per OCRM basis, they are worse. The room count exception can be explained with an example. If there are two hotels with the same number of rooms, LEED will perform worse than Non-LEED hotels. But if two buildings are the same physical size as measured by floor area, then LEED hotels will outperform their non-LEED counterparts. This implies that in public areas and meeting space, LEED buildings are more efficient, which is a logical conclusion given that there is more control over resources consumption in public spaces that comes from the nature of the physical shell of the building than there is in the guestrooms.

A possible conclusion from this data is that guests at LEED buildings are less conscious of resource use because they believe that, by being in a sustainable building, they can afford to use more resources during their stay and generally be less conscious about their environmental impact. They trust their environment to reduce their environmental impact for them, which is not the case. Research has already shown that guests tend to behave much differently in hotels than at home and generally consume more resources in hotels.<sup>109</sup> LEED certification could amplify that effect. All that said, in public areas, LEED certification has more “control” over what a guest does

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<sup>109</sup> Baker, Davis, and Weaver (2014)

and doesn't do so it tends to outperform non-LEED buildings. The second the guest takes control when they arrive at their guestroom, LEED is no longer beneficial.

These findings from holistic analysis of the aggregated CHSB data highlight the fact that LEED certification may have some misalignment with the hotel industry. Again, there is an interesting dichotomy with hotel sustainability in that hotels impact the environment both as a physical structure and as a business operation that runs 24-hours every day of the year. LEED's prescriptive certification scorecard is not designed to handle this dichotomy, which creates a disconnect between it and hotels. LEED is not a test of operational sustainability, it is only a test of structural sustainability, which is arguably less relevant for hoteliers since money is made in hotels mainly from the operations and less from the physical real estate.

As a quick note, despite the fact that most of this data is statistically insignificant, even at a 90% confidence level, these findings are slightly supported by the fact that the 2014 data for "winners" and "losers" of CHSB metrics between LEED and non-LEED, shown in **Appendix Q**, has the same results as 2015. The only exception was water use per occupied room, where LEED hotels used slightly less water than non-LEED hotels.

The only variable that was statistically significant at a 95% confidence level, as determined via single linear regression of the binary LEED certification yes/no variable against the CHSB sustainability metrics for 2015 was water use per square meter of floor area. This regression output is shown in **Appendix O**. From there, every other individually statistically significant variable for water use per square meter of floor area was combined into a multiple regression to test the predictive power of these variables on water use at a hotel. Ultimately, the model had a very low R Square. In fact, per the regression output, shown in **Appendix P**, a person can do a

better job of understanding a hotel's water use by checking the weather (temperature and humidity level, to be exact) than by checking if a hotel was LEED certified or not.

## **Deeper Analysis and Discussion**

The discussion on these following four variables (service type, climate zone, chain scale, and size) is backed by data that can be examined more closely in **Appendix R**.

For service type, the data was broken down further into full-service properties and limited-service properties. The data set is split at about 27% full-service hotels for non-LEED and about 43% full-service hotels for LEED. For all metrics for both service types, LEED hotels outperformed their counterparts. When examining these same metrics on a per occupied room basis, limited-service was still always better for LEED hotels, but for full-service, it was always worse. The operational complexity of a full-service property must be enough to outweigh any benefits of LEED certification when analyzing environmental sustainability.

For climate zone, the data was broken down further into arid, cold, temperate, and tropical climates. It should be noted that the vast majority of hotels exist in temperate climates. Each climate zone was split for metrics where LEED was a "winner" and metrics where LEED was a "loser," except for the arid climate hotels. The data shows that LEED hotels are always superior in arid climates. Also, regardless of climate, LEED hotels outperformed non-LEED hotels for water consumption per square meter, which makes sense given that water per square meter was the only statistically significant variable in the data as determined by single linear regression, even though its predictive power for water use is still extremely low.

For STR chain scale, the data was broken down further into luxury, upper upscale, upscale, and upper midscale. None of the LEED properties were in the midscale of economy chain scales. Also, none of the LEED hotels were military hotels, which remain unclassified by a chain scale. Therefore, this analysis was limited to just the top four chain scales, which are determined by average daily rate. Luxury, Upscale, and Upper Midscale hotels that were LEED certified outperformed their non-LEED counterparts on every metric. Luxury and Upper Midscale were also superior for all metrics when examined on a per occupied room basis. Upper Upscale hotels, on the other hand, were inferior for carbon and water measurements. This data is difficult to analyze because, as with many hotel variables, there is still a lot of variance between hotels in a chain scale. These outcomes may be due to the individual hotels that make up these data sets and have less to do with the meaning that a chain scale may or may not give to sustainability in conjunction with LEED certification.

For area by square meter, the data was broken down further into small, medium, large, and extra-large hotels – classifications that are loosely based on their quartile standing within the broader data sample. As with climate zone, LEED hotels outperformed non-LEED hotels for water consumption per square meter regardless of their size. Large and extra-large hotels also showed consistently better measurements for LEED certified properties across all three of the CHSB sustainability metrics. This may be indicative of some level of economies of scale that LEED certified buildings are able to achieve that is then greatly reduced for smaller buildings. Also, with more areas to heat and cool, the effect of efficient technology in a LEED certified building may be amplified for larger spaces. Comparison of this finding to other building types could be useful to validate this idea.

One final analysis was attempted and the results are shown in **Appendix V**. All data was filtered for in-house vs out-of-house laundry, climate zone (temperate only), chain scale (luxury, upper upscale, upscale, and upper midscale only) and service type. The goal was to examine any major differences that may exist between hotels with in-house laundry and hotels that use a third-party laundry service. An important note on this data is that in the CHSB tool in-house laundry must include bed linens being washed on-property. A hotel that only does restaurant linen in-house would not be classified as having in-house laundry.

The only two metrics that were examined were energy use and water use, both on a per square meter basis. These were determined to be two of the most relevant metrics for the reasons outlined in earlier sections of this paper. The results were the same for both in-house and out-of-house laundry across full-service and limited-service properties, although only in-house laundry results are shown in **Appendix V**. LEED hotels outperformed their non-LEED counterparts for both full and limited-service properties when it came to water use, but only in limited-service properties for energy use. The differences were not too extreme in any of the cases.

Overall, this shows that much of what is being observed in this data is likely more a function of the individual hotels in the sample rather than true trends of LEED versus non-LEED hotels. The heterogeneity that exists between individual hotels across many variables eclipses the substance captured by LEED. The data is complicated and noisy, and exact trends are hard to discern. LEED though, while probably a good certification for hotels to pursue from an internal sustainability standpoint, does not exhibit much utility when it comes to property-to-property comparison for on-property environmental sustainability.

# MONETIZING HOTEL SUSTAINABILITY BEYOND LEED CERTIFICATION

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The following section highlights six “case studies” of ways that hotels can begin to think about sustainability beyond the context of LEED certification, or any other purely building-focused certification, regardless of whether they already have one or not. These cases are meant to highlight hotel innovations that maximize the “triple bottom line,” and serve as fodder for further discussion on any ideas for sustainability in the hotel industry. This includes ideas that are applicable at single hotels in specific geographies as well as ideas that can be extrapolated throughout cities and brands and have impacts that ripple throughout the industry.

## **Hotels and Water – Where Expense Savings Meet Water Security**

As shown in **Appendix B**, LEED v4 currently has requirements for any certification level when it comes to indoor and outdoor water use at a hotel as well as building-level water metering. However, water use in hotels is complex, and there are many ways that water can be saved (or wasted), which together constitute significant amounts. LEED currently does not allocate any specific points for reduction of water in specific parts of the hotel, but small, customized solutions across all departments should still be a priority for hotels. Not only does this set up huge expense savings, but it also contributes to the water security of the surrounding area, an issue that is not discussed often enough in the hotel industry.

The hotel industry has an important role to play in providing water security to the areas where they are located, and in particular with urban environments. Potential sustainability applications to the hotel industry are everywhere, but the brand, owner, and operator discussions driving the industry’s agenda seem to overlook them despite commingled opportunities for financial and

societal gain. Hotels have a responsibility to contribute to community vitality and sustainable development, especially in the realm of urban water security, which is becoming an increasingly salient issue for cities around the world as climate change exacerbates many water-related challenges.

Urban water security is one of the greatest challenges we face today as a global community. We have recently surpassed a point where more than 50% of the world's population is living in urban areas, as defined by the United Nations.<sup>110</sup> The world's urban population grows by two people every second due to people searching for access to sanitation services and clean water.<sup>111</sup> However, city water distribution and sanitation systems are having trouble keeping up with a growing urban population.<sup>112</sup>

Given every person's need for 1000 cubic meters of water per year,<sup>113</sup> it is theoretically possible for everyone on the planet to have enough water based on the amount of annual global rainfall.<sup>114</sup> However, fulfilling this need is difficult in practice, and cities face a unique set of challenges. Some cities must "reach" over 400 kilometers away with water infrastructure to a source of fresh water.<sup>115</sup> By engaging with the hotel industry, where there is currently a lot of opportunity for water efficiency improvement, cities have a chance to reduce vulnerability to water-related challenges.

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<sup>110</sup> United Nations Department of Economic and Social Affairs, Population Division (2014)

<sup>111</sup> United Nations "Water and Urbanization Media Brief" (2010)

<sup>112</sup> World Health Organization (2016)

<sup>113</sup> Rogers, Peter (2016)

<sup>114</sup> Ibid

<sup>115</sup> McDonald (2016)

The chart in **Figure 13** uses the most recent data from the US Geological Survey to show the average breakdown for urban water demand.<sup>116</sup>

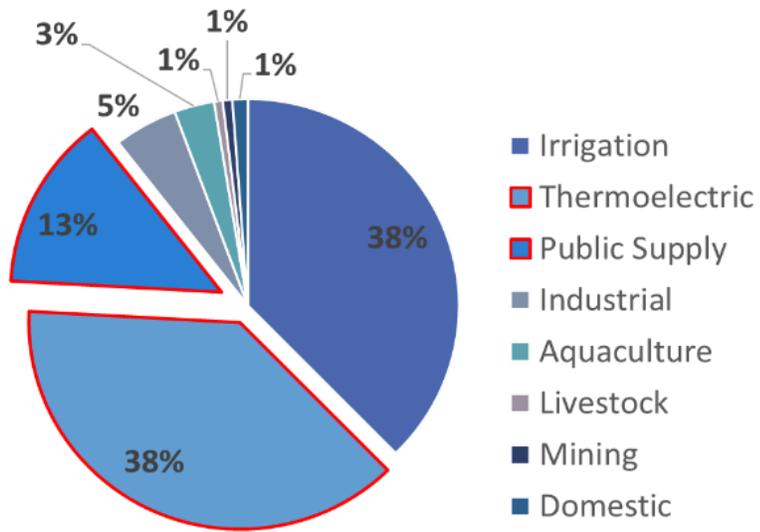


Figure 13: Urban Water Demand by Category (USGS, 2010)

Hotels fall into the category of public

supply, which represents 13% of a city’s water demand. However, public supply is not the only category in which a hotel can have an impact. The Thermolectric category, which includes the water used in the heating and cooling processes needed to generate electricity, represents 38%, on average, of a city’s demand for fresh water, and is the other important category for hotels to consider. Water is thoroughly connected to the energy production process, so by reducing energy consumption, a hotel can reduce a city’s water demand.<sup>117</sup> Also, prioritizing locally sourced food and vegetarian or vegan offerings in a hotel can catalyze reduced water demand in the aquaculture and livestock categories. Managing these categories of city water demand helps to ensure lower water costs and achieve more equitable water distribution by making fresh water available in larger quantities for other domestic uses. It can also reduce the need for additional

<sup>116</sup> US Geological Survey (2010)

<sup>117</sup> The World Bank (2016)

water infrastructure and improve a city’s resilience to climate change by minimizing a city’s reliance on water and making it less vulnerable to water shortages.

Currently, it seems there is a lack of creativity among hotels, especially given that the hospitality industry prides itself on its ability to innovate constantly. This lack of new initiatives is particularly alarming given that hotels consume more than twice as many liters of water per square meter than any other type of real estate.<sup>118</sup> They are also the most intense users of water by volume per dollar value of the building. A hotel uses an estimated 102 gallons of water per guest according to the EPA’s

EnergyStar platform.<sup>119</sup>

This usage is broken down in **Figure 14**.<sup>120</sup>

Rooms (“Domestic/Restroom”)

and Laundry are the two biggest uses of

water at a hotel, which is likely the reason that the vast majority of hotels only pursue two main water efficiency initiatives: low flow or efficient fixtures and linen reuse programs. Estimates indicate that 83% of hotels in the United States have implemented a linen reuse program.<sup>121</sup> This isn’t to say that these widespread programs are a waste of time. In fact, a 200-room hotel, for

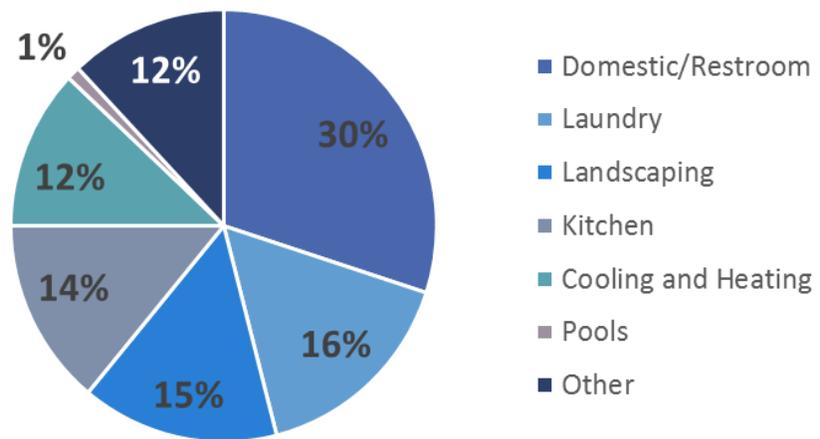


Figure 14: Hotel Water Use by Department (US EPA, 2015)

<sup>118</sup> GRESB (2016)

<sup>119</sup> US EPA “Water Use Tracking” (2012)

<sup>120</sup> US EPA “Saving Water in Hotels” (2015)

<sup>121</sup> Clean Energy Resource Teams (2014)

example, could save as much as \$260,000<sup>122</sup> on linen and water costs over a year with a linen reuse program. This an obvious win-win for the property and the city. Unfortunately, though, most hotels don't look beyond low-flow fixtures and linen reuse to find additional opportunities for reduction of water demand.

The vast majority of water efficiency or demand reduction projects can be viewed as sustainability ROI initiatives that will reduce expenses, boost the bottom line, and improve asset valuation. Water can account for over 10% of a hotel's utility bill, but this could be reduced by up to 50%<sup>123</sup> through conservation activities that require little effort or initial investment. Hoteliers should pursue solutions tailored to a city's specific climate as well as tactics that can be easily extrapolated from city to city.

Given water and energy's inherent relationship, in addition to direct management of water demand, hotels can indirectly improve urban water security by reducing energy demand. Almost every step of the energy production process uses water: extraction, refinement, processing, transport, and power generation.<sup>124</sup> In addition, energy, like water, is a logical place for sustainability focus because of how much more inefficient hotels are compared to other real estate classes.<sup>125</sup>

The World Bank has predicted that by 2035, we will experience a 35% increase in our energy needs, which will cause an 85% increase in our water needs.<sup>126</sup> Therefore, demand management

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<sup>122</sup> Rogers, Reese (2016)

<sup>123</sup> Tuppen (2016)

<sup>124</sup> The World Bank (2016)

<sup>125</sup> GRESB (2016)

<sup>126</sup> The World Bank (2016)

in hotels will be necessary for both utilities. Hotels can continue to lower their water and electricity demand and help to increase a region's water security by incorporating sustainable design features like windows that take advantage of natural light or rooftop gardens that cool internal temperatures and yield fresh produce. For developers, choosing a site that is logical within the context of the urban environment allows for ease of connectivity to water and energy sources. Being proximate to the city center may allow a property to better leverage the economies of scale.

Driving changes in urban water security at the hotel level begins with the implementation of systems for measuring and adapting. Hotels have struggled in the past to find ways to measure their eco-footprint. For example, 40% of hotels were not even measuring a basic metric like water consumption.<sup>127</sup> More focus on data will lead to improved metrics, and eventually, industry stakeholders will begin to realize that “going green” is not just a fleeting trend or a marketing scheme, but rather a thoughtful and logical way to save money. When it comes to water, hotels have countless opportunities to not only improve their bottom line and increase the value of the real estate but also play an important role in a city's vitality and the health of the community.

### **The Buzz about Bees – Revenue & Branding from On-Property Beekeeping**

On-property beekeeping is a rising trend throughout the United States in hotels of all sizes, geographies, and brand affiliations. Incorporation of on-property beekeeping in hotels will help them to achieve the following benefits: enhanced guest experience, strengthened brand identity, and strengthened regional bee populations.

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<sup>127</sup> Hughes (2015)

Bees are one of the most important insects to the survival of human beings. They are key members of nearly every food web and food system from an ecological perspective, and that importance extends to human beings, given that 75% of food relies on pollinators.<sup>128</sup> There are numerous agricultural products that rely heavily on pollination specifically from bees, as seen in **Figure 15**.<sup>129</sup> According to the US Department of Agriculture, bee pollination creates about \$14 billion in economic value for the United States alone.<sup>130</sup> Benefits of bees are far-reaching into so many aspects of society, or more simply, human survival, which makes them incredibly important to protect.

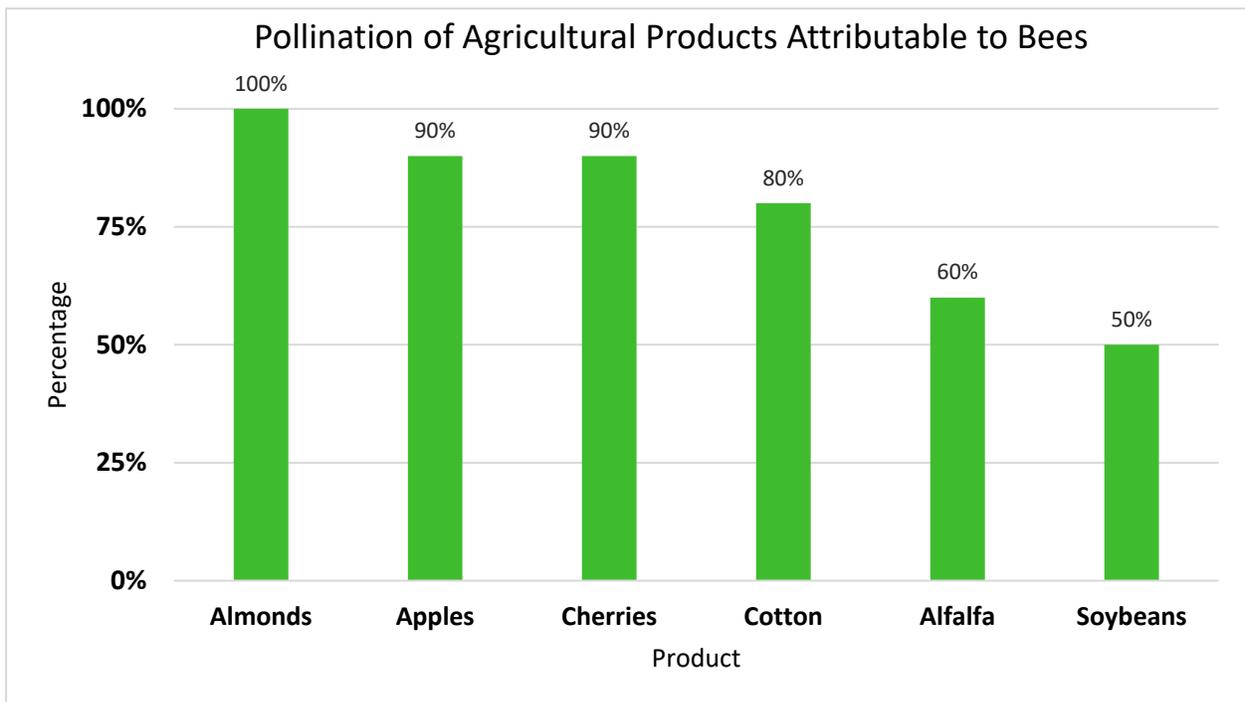


Figure 15: Agricultural Products Reliant on Bee Pollination (USDA, 2007)

Scientists have not been able to say with certainty what the exact causes of the bee population decline are, although many scientists point to climate change and intense pesticide use, both of

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<sup>128</sup> Greshko (2017)

<sup>129</sup> USDA (2007)

<sup>130</sup> Mukerjee (2014)

which are indirectly related to colony collapse disorder, in which entire colonies of bees experience sudden mass die-offs.<sup>131</sup> As of March 21<sup>st</sup>, 2017, the Rusty Patched Bumble Name, officially known by its scientific name *Bombus Affinis*, became the first continental US-based species of bee to be added to the Endangered Species List, and it is now protected under the Endangered Species Act of 1973.<sup>132</sup> This came about after this species experienced 87% population decline in just 20 years.<sup>133</sup> Although this species of bee used to be present in 28 states across the Midwestern and Eastern United States, its population has suffered greatly and has now been reduced to only 13 states.<sup>134</sup> Adding *Bombus Affinis* to the Endangered Species List is a big step in a positive direction regarding the environment receiving much-needed support from the federal government, but there is still more than can be done. Like many environmental challenges though, this challenge presents hotels with a unique opportunity to innovate creatively and help contribute to a solution.

On-property beekeeping presents a clear, tangible way for hotels to engage directly with an environmental issue. This new trend is accompanied by numerous opportunities for hotels to increase the strength of their brand, enhance the guest experience, and create new revenue streams from engagement with both guests at their property and the local community, all while supporting bee populations in their local areas and the environment as a whole.

Regarding the guest experience, a primary concern of hotel owners and operators when they first learn about on-property beekeeping is the potential liability for stinging. First, it should be made

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<sup>131</sup> Hagopian (2017)

<sup>132</sup> USFW “Fact Sheet – Rusty Patched Bumble Bee” (2017)

<sup>133</sup> Greshko (2017)

<sup>134</sup> Ibid

clear to both guests and staff members that honey bees and bumble bees, which are the two prime candidates of bee species for on-property beekeeping, are also the least likely to sting.<sup>135</sup> They should not be confused with their more aggressive counterparts in the insect world like wasps, hornets, or yellow jackets. Second, hotel properties can easily and inexpensively stock products at the front desk that can be used in case of emergency, which will help to mitigate any legal risks.

Numerous other benefits to the overall guest experience can stem from having bees at a hotel. Bees are great pollinators, and therefore will be a big help with all other vegetation in and around hotels.<sup>136</sup> Bees can help to keep flowers and other landscaping looking vibrant at no extra cost.<sup>137</sup> Additionally, many hotels either currently have gardens for their kitchens to use as a source of fresh produce and herbs, or are planning to grow one. Again, these bees will be immensely helpful in maintaining healthy, active property gardens given they are prolific pollinators.

Since beehives tend to be highly self-sufficient, there will be few staffing needs for on-property beekeeping, which will allow hotels to maintain a focus on core operations. Also, the bees will not be a distraction for guests since they will be primarily out of sight. Having an on-staff beekeeper is an option, but there are also freelance beekeepers that hotels could contract; regardless, this does not need to be a labor-intensive process for any properties.

One obvious benefit can be easily incorporated into the guest experience: honey. Hotels have created entire themes around on-property bees and honey.<sup>138</sup> Hotels can also encourage guests

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<sup>135</sup> Mukerjee (2014)

<sup>136</sup> Greshko (2017)

<sup>137</sup> Mest (2016)

<sup>138</sup> Mest (2016)

to engage with the bees in a more hands-on manner to create a unique, memorable experience for all ages. Modern-day beekeeping has advanced enough to be very safe and easy to do. Keeping a few beekeeper suits on-hand at the properties will allow guests to interact directly with the bees (under supervision). An experience like that would be almost impossible to recreate and it would leave a great impression on the guest. On-property beekeeping is feasible and sustainable for hotels of all sizes, chain scales, target demographics, geographies, and brands.<sup>139</sup> It has little downside or financial impact – the challenge comes in finding ways to creatively leverage rooftop bees to have memorable experiences for the guests, as well as finding a way to engage with the bees rather than simply having them sit passively on the roof.

One element of on-property beekeeping that would make it easily implementable at a hotel is its low cost of installation. Rooftop beehives do not require expensive installation or materials and do not require any kind of shutdown or interruption to daily operations. Although exact costs depend on region and desired hive size, most hotels spend under \$1000 to install a hive and then approximately \$200 annually in colony maintenance and upkeep.<sup>140</sup>

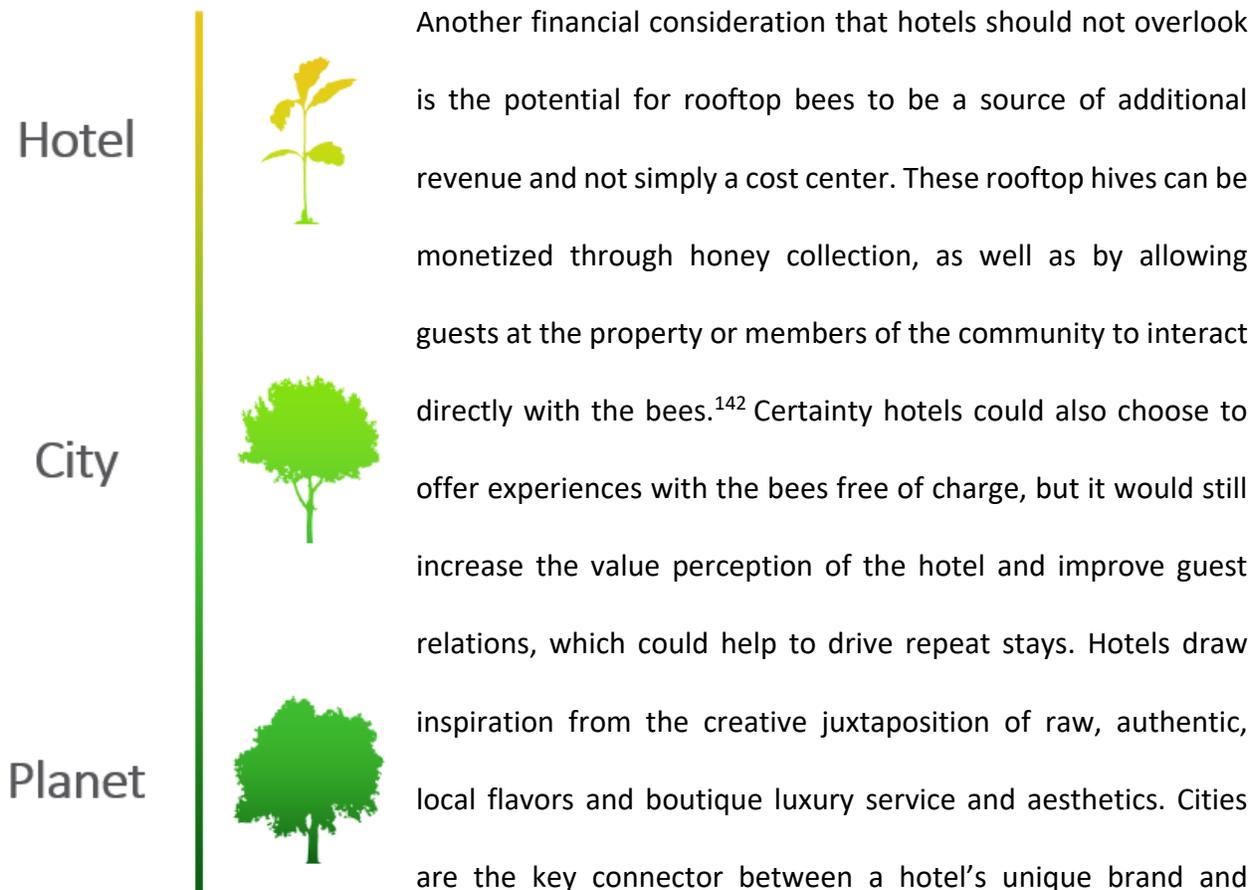
Some hotel owners and operators are hesitant to install rooftop bees because of concerns about space obligations. However, rooftop hives take up very little room and very self-contained, so they would not interfere with any HVAC equipment, rooftop gardens, or even guest features on a roof like a pool or a bar.<sup>141</sup> The opportunity cost of the space is low for the amount of value that rooftop beekeeping creates.

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<sup>139</sup> Ibid

<sup>140</sup> Urban Bees FAQ (2017)

<sup>141</sup> Urban Bees FAQ (2017)



*Figure 16: Levels of Innovation for Hoteliers to Consider (custom graphic, 2017)*

Another financial consideration that hotels should not overlook is the potential for rooftop bees to be a source of additional revenue and not simply a cost center. These rooftop hives can be monetized through honey collection, as well as by allowing guests at the property or members of the community to interact directly with the bees.<sup>142</sup> Certainly hotels could also choose to offer experiences with the bees free of charge, but it would still increase the value perception of the hotel and improve guest relations, which could help to drive repeat stays. Hotels draw inspiration from the creative juxtaposition of raw, authentic, local flavors and boutique luxury service and aesthetics. Cities are the key connector between a hotel’s unique brand and memorable guest experience. Furthermore, it is nearly impossible to put a price on the value of positive public relations,

but positive public perception has direct impacts on a hotel’s bottom line. Rooftop beekeeping would certainly be looked on favorably, and maintaining good relationships with community members and city stakeholders could help to drive additional revenue, especially by hosting local events.

The hotel industry has an important role to play in this issue, and it can begin by acknowledging its responsibility to have a stake in a key environmental solution such as on-property beekeeping

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<sup>142</sup> Thompson (2015)

to help support the *Bombus Affinis* and other species. Hotels are incredibly dynamic spaces that can help bring people and ideas together. Small solutions like this can help hotels to reciprocate the inherent support that the environment offers. This is a chance for hotels to provide an authentic experience, local engagement, and experience-driven memories. This can also help guests to “transcend the stay”<sup>143</sup> by finding meaning in a room night beyond just a good night’s sleep. Guests should leave feeling content and connected to the small pieces of local charm that make each city special. Ideas like this help to create a competitive advantage, especially at boutique lifestyle hotels that bring together luxury hospitality and local charm. Small ideas and impactful, thoughtful initiatives like on-property beekeeping help to establish a hotel as a leader in its community and the industry.

### **Crowdfunding Sustainability – Offsetting Carbon through Shared Value Creation**

Crowdfunding sustainability in hotels is an emerging trend, but the idea of togetherness in the hotel industry has been at its core since the very beginning. Our world is more connected every day, especially with the rate at which technology is advancing. Hotels are uniquely positioned to capture this interconnectedness, combine it with togetherness, and apply it to a global issue like sustainability in the form of crowdsourcing. Media company PSFK declared in 2014 that “crowdsourced hotel design will be the future” during their work on a partnership with Prodigy Network, a real estate crowdfunding company that had taken on a project to design the first “Cotel.”<sup>144</sup> This hotel hopes to drive inspiration for everything from its rooms to its public spaces

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<sup>143</sup> Aparium Hotels (2017)

<sup>144</sup> PSFK (2014)

from “the crowd,” which will hopefully include sustainable design features. However, there are also much more direct ways for combining crowdfunding, hotels, and sustainability.



Figure 17: EcoStay logo (EcoStay, 2017)

EcoStay is one of the outcomes of these ideas. EcoStay is a highly innovative and exceptionally logical method of money flows that combines sustainability and

hospitality. EcoStay’s model involves an opt-in opportunity for every guest at hotels that have engaged with EcoStay as a third-party partner.<sup>145</sup> The guest can choose to add two dollars to their bill to offset the carbon footprint involved with their stay. All of that money then goes to EcoStay, of which fifty cents is put aside in an escrow fund for the hotel’s CapEx projects, and the remaining money goes toward local projects that directly offset the carbon cost of one night at a hotel.<sup>146</sup> This breakdown is shown in **Figure 18**. Their main project is the EcoStay Motherland Forest, a reforestation project that will also include elements of education and cultural heritage. Each tree will be directly tied back to the hotel industry.<sup>147</sup> Hotels can then use the money in their escrow fund, which, having come from a guest, is essentially free money, to help finance CapEx projects (only if they are related to carbon footprint reduction) like efficient HVAC units, lighting retrofits, and other expensive projects that a hotel might normally deprioritize due to cost, but can now complete with ease.

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<sup>145</sup> EcoStay (2017)

<sup>146</sup> Ibid

<sup>147</sup> Ibid

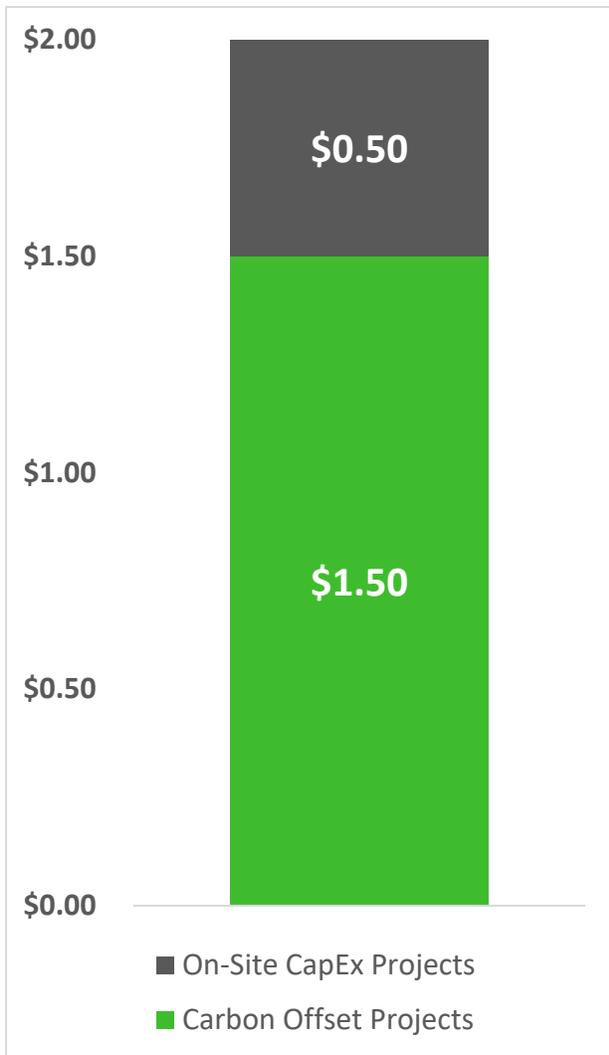


Figure 18: Crowdfunding Breakdown per Guest Participant with EcoStay (EcoStay, 2017)

EcoStay recognizes that, despite significant recent progress in the hotel industry, there is still a long way to go and a lot that can be done regarding sustainability. By eliminating the financial burden of environmentally-friendly initiatives at the property level, EcoStay is effectively using crowdsourcing to reduce the carbon footprint of the hotel industry. They refer to this process as “shared value creation,”<sup>148</sup> because every element of the concentric circle model – environment, economy, and society, stands to gain from a negligible financial cost to individual hotel guests.

LEED is effective for a laser-focus on sustainability at one property and one building, but when it comes to hotels, sustainability truly starts with people and human connections. Thinking beyond cash flows at a single property and instead thinking of ways to engage with guests and pursue sustainability with an undertone of communal strength is an incredibly powerful mechanism that EcoStay has captured perfectly with its model.

<sup>148</sup> EcoStay (2017)

## Reimagining OTAs – Booking Websites’ Shift to Sustainable Hotels

OTAs are already trying to meet owners and operators in the middle when it comes to vertical integration of sustainability in the hotel industry. Increasing numbers of guests want to book a hotel room with the environment in mind – as many as 79%, according to a 2013 survey.<sup>149</sup> Many hotels have been looking for ways to implement sustainability in their operations, especially with simple, classic examples such as linen reuse. However, research has shown that customers are skeptical of practices like linen reuse that clearly have an ulterior motive of saving money for the hotel.<sup>150</sup> For hotels that are serious about bringing their sustainable practices directly to the guest, new and exciting OTAs are ready and waiting for hotel participation. This practice then becomes a double benefit because hotels are attracting guests who already care about the environment and are more likely to take care of the property during their stay.

Some models like TripAdvisor’s GreenLeaders program seek only to feature green hotels, so hotel guests that are serious about the environment go right to more specialized websites.<sup>151</sup> There is tremendous variety in OTAs that specialize in green hotel listings, and hotels should seek to be listed on as many as possible of these sites, especially if they have incorporated unique elements of sustainability in their property or branding strategy, in order to increase exposure and drive revenue to their door. One site that has gained recent popularity is Bookdifferent.com, which lists hotels alongside their carbon footprints. They currently have nearly one million hotel rooms

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<sup>149</sup> Rahman, Park, and Chi (2015)

<sup>150</sup> Ibid

<sup>151</sup> Beachmeter.com (2017)

represented on their site, and 10% of the profit from each booking is donated directly to a sustainable tourism organization.<sup>152</sup>

Other sites require hotels to apply to be listed. Kindtraveler.com is one such site that is focused on the boutique and independent hotel segment given its natural resonance with integrating authentically into the community.<sup>153</sup> When joining the platform, all hotels must choose a local charity in their community that they want to display on their microsite, giving the travelers the opportunity to make a difference locally. With a \$10 donation, travelers can give back to that local charity, or to a favorite charity on the Kind Traveler platform. This donation unlocks exclusive hotel rates, anywhere between 10-25 percent off of the standard rate. The traveler is then able to complete the final booking with the “Kind Traveler Exclusive Rate” in lieu of a donation, with 100% of donations going to charities.<sup>154</sup> More research is needed to understand fully how these eco-specialized OTAs have penetrated the market and grabbed bookings from giants like Expedia or Priceline, but research does show that hotel guests are interested in environmentally friendly stays. Hotels can bring their sustainability right to the guest before the guest even steps foot on-property by building partnerships with green booking sites. LEED certification can help hotels to get listed on these sites and build out sustainability platforms, but OTAs can help the hotels co-create a sustainable experience.

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<sup>152</sup> Bookdifferent.com (2017)

<sup>153</sup> Kind Traveler (2017)

<sup>154</sup> Ibid

## Technology and Building Management – Data from the Internet of Things

Many hotels across the globe are searching for a way to re-energize their focus on efficient property management and environmental sustainability. Currently, a lot of important data on building operations and energy use is being locked away in old technologies that do not allow access to the data that they store, if any, without going through a clunky or outdated process.<sup>155</sup> Things like HVAC units, water heaters, and even light bulbs are keys to energy efficiency in hotels, and without knowing how they're performing, it is impossible to manage and optimize their use. This idea is commonly known as the creation of "smart" devices.

The Internet of Things is a new technology trend that is increasing data transparency and quality across numerous industries, and it is highly applicable to building management software as well. Daniel Burrus, founder and CEO of Burrus Research and technology innovation expert, reports that "The Internet of Things revolves around increased machine-to-machine communication; it's built on cloud computing and networks of data-gathering sensors; it's mobile, virtual, and instantaneous connection."<sup>156</sup> Senseware, a company based in Virginia, is just one example of a technology platform that could allow hotels to unlock critical building-level data on water, energy, and HVAC levels, as seen in **Figure 19**.<sup>157</sup> Being LEED certified is one thing, but after achieving certification, truly sustainable hotels need to be able to continue to monitor their performance – this can help to mitigate the criticism of LEED that it requires no post-certification follow-up.

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<sup>155</sup> Senseware (2017)

<sup>156</sup> Burrus (2014)

<sup>157</sup> Senseware (2017)

Hotels and hotel companies would accomplish three goals through the portfolio-wide use of Senseware or other technologies that are enabled with the Internet of Things:

- Save money across portfolio & create shareholder value
- Establish industry trends & unlock hotels' potential
- Improve community health & sustainable urbanism



Figure 19: Senseware Dashboard Sample (Senseware, 2017)

Building management systems that leverage the Internet of Things offer quicker returns on investment than traditional building management systems, and with shorter ROIs than traditional building management systems, these systems can both reduce monthly expenses and increase asset value.<sup>158</sup>

Traditional building management cost approximately \$2.50 per square foot for installation and upkeep, whereas Senseware and other IoT systems cost approximately \$0.75 per square foot for installation and upkeep, which could yield approximately a two-year payback for a hotel.<sup>159</sup> One average-sized, full-service hotel could save approximately \$42,000 per year with Senseware technology.<sup>160</sup>

<sup>158</sup> Raschke (2017)  
<sup>159</sup> Ibid  
<sup>160</sup> Ibid

Industry stakeholders are currently overlooking this opportunity for commingled financial and societal gain. Property and asset managers can easily access and analyze data outputs from a system enabled with Internet of Things in real time. Those insights can not only improve hotel property and company financial performance, but also augment communal sustainability in the local area where the hotel is located. Decreased utility demand can lower costs for the region's residents, improve equitable distribution,<sup>161</sup> reduce the need for additional city-wide infrastructure,<sup>162</sup> and improve climate resilience of the community.<sup>163</sup>

InterContinental Hotel Group has implemented a building management system for internal use called Green Engage. Not only does this serve as a tool for property managers to use to track energy consumption at a property, but it also helps corporate-level sustainability managers to compare properties and rank them based on their energy use. All IHG properties are required to achieve the "level one" rank through Green Engage, and "can choose from over 200 'Green Solutions' that are designed to help them reduce their energy, water, and waste, and improve their impact on the environment" as they pursue that goal.<sup>164</sup>

Implementation of a program like Green Engage is a great step to allow hotels to measure and manage their environmental impact, and it's made even easier by the fact that it's available online.<sup>165</sup> However, the opportunity for even greater data transparency and impact management is within IHG's grasp. Combining a property management system with the Internet of Things

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<sup>161</sup> Rogers, Peter (2016)

<sup>162</sup> McDonald (2016)

<sup>163</sup> UN "Water and Cities" (2017)

<sup>164</sup> IHG (2016)

<sup>165</sup> Ibid

would allow a hotel company to have unprecedented access to their own data, and therefore, superior energy management strategies that could help create a competitive advantage, save costs, and establish the brand as a leader at the intersection of hospitality and utility management.

### **Impact Investing – Commingled Financial & Ecological Gains in the Hotel Industry**

Impact investing, also known as the “pay for success” model, is a type of investment activity involving “investments made into companies, organizations, and funds with the intention to generate social and environmental impact alongside a financial return.”<sup>166</sup> This is a relatively new field that captures not only the theme of responsibility but also the themes of education and innovation, both of which are highly relevant to hotel owners and operators alike. These themes are important to help hoteliers begin to grapple with the interconnectivity of the world through an operational lens and a real estate investment lens. Impact investing adds another layer of thought, reflection, and analysis that simultaneously elucidates and complicates the practice of sustainable finance and development for the hotel industry.

Social Impact Bonds and impact investing challenge the traditional venture capital or equity investment model – sometimes referred to as the “finance-first” model<sup>167</sup> – that is typically seen with hotel ownership because that model isn’t always effective with socially responsible or socially impactful business. Many for-profit firms are now pursuing “evidence-based interventions” in their platforms with the goal of “permanizing” the impact investment industry

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<sup>166</sup> GIIN (2017)

<sup>167</sup> Terry (2010)

and proving the inherent value of service providers.<sup>168</sup> These firms evaluate service providers or businesses for a social impact, determine who is helped or who saves money because of what the service provider does, and then fund the expansion of the service provider, using a third-party evaluator to quantify the impact of the expansion of the service provider's ability to do the thing that they exist to do. A key part of their model is that there is no real risk for the party who benefits from the work of the service provider. Because of these key tenets, "while this market is still relatively new, investors are optimistic overall about its development and expect increased scale and efficiency in the future."<sup>169</sup>

The hospitality industry is one place where this growth might be possible. The broad service industry is the largest employer in the world,<sup>170</sup> and there is very accurate data to explain what is happening within. For the hotel industry in particular, there is "an enviable volume and variety to work with" relative to other industries.<sup>171</sup> ImpactAssets, a nonprofit financial services firm focused on impact investing, notes in a recent Issue Brief, "measurement and evaluation of impact continue to confound practitioners...and there are still significant challenges in understanding how outputs... may be translated into outcomes."<sup>172</sup>

The conversation surrounding the impact investing realm and the hotel industry is changing, but more private sector involvement could act as a catalyst for broader change, and not just on a case-by-case basis. For example, money can be made with companies who fund food recycling

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<sup>168</sup> Gaztambide (2016)

<sup>169</sup> GIIN (2017)

<sup>170</sup> USDL Bureau of Labor Statistics (2017)

<sup>171</sup> Marr (2017)

<sup>172</sup> Smalling and Emerson (2017)

programs at hotels, or at properties who are in need of a sustainability update but don't have the free cash flow available to fund any retroactive or forward-looking change. Overall, investors are trying to instate "profit-seeking investment to generate social and environmental good is moving from a periphery of activist investors to the core of mainstream financial institutions,"<sup>173</sup> so why can't hotels be the platform on which those investments are brought out of the periphery?

Just as they are regarding sustainability, hotels would be a highly logical choice as a target industry for increased impact investment. The World Bank has had a hand in investing in the hotel industry as a means of development, and they note that "while the direct benefits from hotels are easier to measure, indirect benefits are key."<sup>174</sup> Based on their experience in this sector, as well as other examples of impact investment in hotels, they see impactfully-minded hotel investments as having "a catalytic effect on boosting a country's tourism sector and contributing to its economic diversification and sustainable growth."<sup>175</sup> Specifically, hotel impact investments can yield the following benefits:<sup>176</sup>

- Exchange of foreign currency
- Improvement of cultural heritage sites
- Transfer of knowledge and skills
- Collection of taxes by the government
- Improved fire and life safety standards
- Improvements in the local environment

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<sup>173</sup> Freireich and Fulton (2009)

<sup>174</sup> IFC (2017)

<sup>175</sup> Ibid

<sup>176</sup> Ibid

- Improvements to local transportation and infrastructure'
- Job creation opportunities, both direct and indirect
- Linkages with local suppliers
- Contributions to environmental conservation

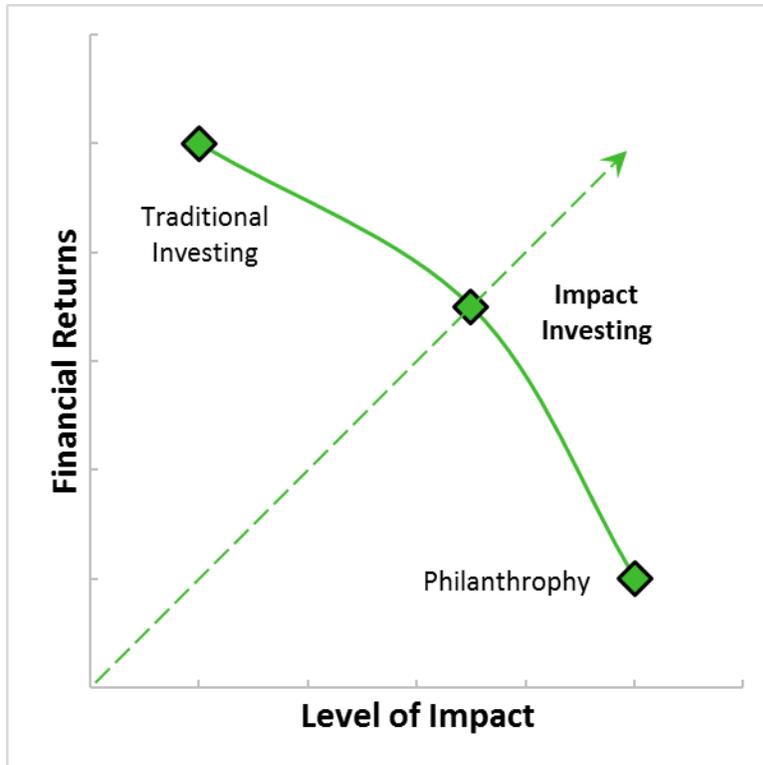


Figure 20: Impact Investing Returns and Impact Comparison (custom graphic, Adapted from Monitor Institute, 2017)

Different projects will generate different impacts in different areas of the world, but the overall goal is to find a way to capture one of those improvements, find a way that it saves the area money or generates revenue, and then make a return on the investment based on the economic value being created by the hotel. Certainly, hotels can be risky investments, but they also have the potential to

carry the greatest amount of environmental utility and positive influence.

There are some restrictions to impact investing that need to be acknowledged. First, evidence-based interventions are not a one-size-fits-all solution, they only work when appropriate. They depend heavily on the quantity and quality of data provided by the service provider, but getting data from a service provider is also an issue. For most businesses, strict data collection standards aren't a priority, especially for non-profits who have to control their administrative expenses. The

system around the service provider hurts them and doesn't provide an incentive to collect data effectively. ImpactAssets asserts that "a strong commitment to transparency and ongoing evaluation is essential to maintaining the integrity of impact investing and its potential to be truly transformative in addressing global challenges."<sup>177</sup> Perhaps the hotel industry could be the partner that they are looking for as the next frontier of impact investing. Second, the service provider may not actually be ready to expand or be truly good at what they do. This would hurt the returns of the bond. Third, a lot of weight is put on the 3<sup>rd</sup> party evaluator's shoulders. There is a lot of pressure to prove causation in nebulous social justice issues between the service provider and the party benefitting from their work. Finding appropriate evidence is often difficult and subjective. Fourth, as an industry and as an asset class, impact investing is still struggling to take off. There is a large disparity between capital that wants to be put to work and availability of good deals that can generate decent returns. Investors are actively seeking to "place capital in businesses and funds that can provide solutions at a scale that purely philanthropic interventions usually cannot reach."<sup>178</sup> That said, even though there are many places and businesses where money is needed, the due diligence required to actually make a substantial investment provides a very fine filter for potential investment opportunities.

The paradox of sustainable development challenges us to find a cooperative, synergistic approach between environmental conservation and economic growth. Right now, it seems as though we're trying to find a balance instead of a solution, which creates a zero-sum game in our planet. An impact investment firm's business model presents a tangible way to find a cooperative

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<sup>177</sup> Smalling and Emerson (2015)

<sup>178</sup> Freireich and Fulton (2009)

approach to sustainable development by finding investors willing to provide capital and take on risk (economic) to unstick problems and push through toward a solution (social and environmental). In the concentric circle model, the support comes from the inside out, and the framework comes from the outside in.

The idea that it is possible to pay for success brings up two important questions. First, how are we defining “success?” Second, and probably more importantly, who is going to be “paying?” The “pay for success” model is brought about through the idea that traditional banks generally don’t want the types of deals that impact investors target, but their clients still want to feel good about their money. This idea is rooted in the “cocktail party story,” in which investors want deals to reflect their values to be able to talk about them to their friends.<sup>179</sup>

For now, success exists on a case-by-case basis. The industry simply isn’t widespread or developed enough to have changed the landscape of the investing world and moved the center of gravity away from investments in more traditional asset classes. The payment aspect right now is limited to individuals interested in the “cocktail party story.” However, a distinction should be made between whether they are paying *because of success* with regards to the service provider, or whether they are paying *in order to achieve* success of the service provider. It seems like it is the former, which theoretically would limit the risk of deals given past success. However, these deals are still very risky, and their risk-adjusted returns are still very low, because it is difficult to make money on something that is already happening. In many ways, this asset class is unique. Other asset classes require investors to gamble on the inherent uncertainty of the future, but

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<sup>179</sup> Gaztambide (2016)

impact investments seem to place more emphasis on examination of past results to see if even more value can be created and to see if a successful system can be further monetized.

Complacency and close-mindedness are no longer options if we expect future generations to be able to continue to grow and develop in the world as we have been able to for centuries. Therefore, we as a global community must acknowledge and act upon our responsibility, which begins with becoming educated in the way our world works. By understanding the core elements of development and sustainability, we can begin to piece together our individual role in these very complex systems. The hotel industry also shares in that responsibility to make itself available and open to impactful investment initiatives to help spread the good that a hotel can do for a person, a community, or even a whole country.

Solutions to problems come from mutations at the extreme ends of a system, not from further exploration of a paradigm that no longer functions as it should. As one impact investment leader believes, “the world doesn’t need more people with big hearts, it needs more people who can put context to their education.”<sup>180</sup> It’s important to understand certain disciplines at a very deep level, but we can’t become so far removed from the rest of the world that we lose the context of our goals as a planet and a population, such as longevity, progress, and happiness.

Bridging the gaps in our knowledge with new perspectives and forward-looking ideas is the only way to find effective solutions. Impact investment is a new perspective for the hotel industry, especially in the realm of sustainability, just like hoteliers would have new perspectives to share with impact investors. However, ultimately, we all have a responsibility to solve the problems at

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<sup>180</sup> Gaztambide (2016)

hand. How or why or who caused them is no longer the question. Looking behind ourselves and wondering what happened is no longer productive, and instead, we should be mainly concerned with how the human race can adapt and move forward, and how our mindset needs to evolve in order to accomplish that goal. Discussion, reflection, and critical thinking are an effective way to engage with new models like the impact investing model and begin to tackle the world's biggest problems creatively.

### **Summary of Monetizing Hotel Sustainability beyond LEED Certification**

As has been demonstrated and discussed at length in this section, there are almost infinite possibilities for a hotel that wishes to engage in sustainable practices without binding itself to the prescriptive LEED criteria, or for a hotel that already has received LEED certification but is looking to increase its sustainability levels and reduce resource use intensity in other areas of operations and management. Creativity, multidisciplinary thought, vertical integration, and cross-industry partnerships and collaboration can go a long way in advancing the sustainability agenda of the hotel industry. This section has shown ways for hotels to implement changes across the following categories:

- Utility expense savings
- Revenue generation
- Branding and authenticity marketing
- Capital expenditure financing
- Technology implementation
- Building management software

- OTA bookings
- Competitive advantage creation
- Attraction of impact investment

All of these show how sustainability can cross-cut so many aspects of running or owning a hotel with just a little bit of ingenuity, critical thinking, analysis, reflection, and self-awareness.

## CONCLUSIONS AND FURTHER RESEARCH

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### Summary of Findings

Overall, these results show two things. First, they demonstrate that further analysis is needed before LEED certification can be used effectively as evidence for superior on-property environmental sustainability between hotels. Statistical significance aside, the data showed that LEED hotels do not always outperform their relevant counterparts when measuring carbon, water, and energy. Second, the true impact of LEED is extremely difficult to determine for hotels with any method besides direct comparison of hotel metrics before and after LEED certification. The inherent heterogeneity of data in this sample, just like in the broader hotel industry, brings with it a lot of extra variance besides just LEED certification. This inherent variance dwarfs any meaningful level of variance that might come from LEED certification.

These overall results may be important for hoteliers as well as for the USGBC. In their research, Esparon et al perceive that “the success of certification schemes depends on consumers’ confidence in the quality of the products and services that the schemes endorse.”<sup>181</sup> LEED doesn’t necessarily make a claim that they endorse the best hotels in the US when it comes to sustainability, but with the data from this study, making that claim would be more difficult now if the USGBC ever decided to use that as a marketing tactic. Customers would realize more that LEED doesn’t mark the “best” hotels for sustainability, and therefore, the certification would be reduced to just that: a certification that the hotel hit an objective level of quality, and not a

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<sup>181</sup> Esparon, Gyuris, and Stoeckl (2014)

symbol of environmental superiority over other hotels in the area. The Center for Sustainable Tourism and Ecotourism perhaps puts it best when they say, “certification is not an end in itself [but rather] it is one of a number of tools for motivating businesses and others to improve their environmental, social, and economic performance while rewarding them for doing so.”<sup>182</sup>

### **Opportunities for Further Exploration of Data and Research Extensions**

With this current data, there are many opportunities for further exploration and analysis. First, many of the carbon footprint measures for each hotel are not as useful as the water and energy use metrics, both per occupied room as well as per square meter, due to the vast differences in carbon footprint that are inherent in various geographies. The emission factor to convert electricity to CO<sub>2</sub> varies across the US, up to a factor of 4x from one region to the next. By separating observations out either by metro area, or more broadly, by region, carbon footprint metrics could become more “apples to apples” and therefore be more relevant data. There are additional opportunities to cut through the data using qualitative variables such as in-house laundry use, climate zone, asset type, and others, or even making multiple layers of cuts and data batches depending on the availability of observations. Two variables within LEED hotels that were not examined during this study were LEED-EB versus LEED-NC buildings, as well as the actual certification level achieved by the hotel. These variables were not separated out in an effort to maintain large enough groupings of data to be relevant, but these variables are available, and given enough data, could offer some insight on the ideal level of LEED certification for a hotel to pursue dependent on the kind of certification project being undertaken.

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<sup>182</sup> CESB (2008)

Regression, both linear and logistic, could be useful in this context to better understand the predictive power of these variables on the sustainability metrics of a hotel. As was discussed, the majority of the observations discussed here were not statistically significant at a 95% confidence interval, but further examination of the data and more thoughtful batches could yield more statistically significant results on the differences between LEED and non-LEED hotels, both for the sustainability metrics, as well as for other variables. One particular application of a regression model could be identifying the impact of weather on resource consumption metrics and carbon footprint, and comparing that to LEED certification to understand how to adjust data analysis between hotels in different regions for the different types of weather they experience, including temperature, humidity, days of sun, and rainfall.

A research method similar to the method used by Walsman et al in “The Impact of LEED Certification on Hotel Performance” in 2014 would be an ideal extension of this current research. Finding “twin hotels” or other methods of creating comparable sets of properties still leaves room for a lot of heterogeneity that can spoil a data set. Even the most meticulous creation of comparable data sets allows for discrepancies and noise to sneak in and twist any potential findings. Two hotels of the same size and brand that are next to each other on a street in the same city can still be vastly different with staff, management, quality, cleanliness, and even just the type of people that walk in and out of the door. By examining a set of hotels that go from not being LEED certified at first but then later undergo the necessary steps to obtain the certification would make for a highly useful set of data, because then the impact of the certification and its requirements are much more isolated, with so many other hotel-related factors being controlled for simply by being the same property (and likely the same management, brand, size, customer

makeup, etc.). If it were possible to conduct a similar study with the CSHB data and monitor a group of hotels over time as they went from being non-LEED to LEED hotels, that data and analysis could be very telling of LEED certification's impact on hotel sustainability metrics, or at the very least an interesting perspective to contribute to the ongoing discussion.

Lastly, one separate-but-related study that was being examined concurrently with the one presented in this paper was an examination of the impact of LEED certification on hotel profitability (as an extension of the revenue-focused 2014 study done by Walsman et al) using pro forma data from providers like CBRE or STR. Although much more careful analysis would be required, it appears that LEED hotels, in most submarkets, enjoy reduced expenses driven in part by lower property maintenance costs, but more so by lower utility costs, both on a per available room basis. This could contribute significantly to the discussion of LEED hotels and utility consumption, as well as an examination of LEED's effects on a per total room count basis versus a per occupied room basis.

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## Closing Remarks

Hoteliers may stray away from multidisciplinary initiatives like LEED or other green building certifications because they struggle to see a connection between two seemingly discrete worlds. Why should the environmental impact of a hotel be so important a concern to industry players whose top priority is financial well-being? Upon further examination and reflection, these two worlds are not as dissimilar as they may seem at first. Sustainability and Hospitality share the core values of persistent innovation, constant reinvention, and most importantly, service. That includes service not only to our fellow man, but also service to the planet itself.

Ultimately, LEED Certification in hotels is not a “solution” to a “problem” that exists in our world and our planet. Sustainability is a highly complex, multifaceted topic that draws on knowledge from many disciplines in order to grapple with deep-rooted environmental issues. There is no “solution” to these issues, but rather these issues necessitate a deep cultural paradigm shift within our society. LEED Certification, or more broadly, environmental sustainability in hotels is a seemingly small piece of the puzzle, but to overlook its benefits, ecological, social, financial, or otherwise, is to ignore the responsibility that the hotel industry has to the planet. In a way, LEED Certification highlights a way that human beings are able to respond to environmental challenges. We seek tangible and easily understood applications of environmental sustainability that optimize the balance of human effort and environmental utility. LEED is not a solution to a problem, but rather one example of a tangible application of sustainability – an attempt to guide the efforts of hoteliers hoping to have more sustainability properties in a way that works best for them and for the planet.

## LIST OF REFERENCES

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- Aparium Hotels Inc., "Hotels," Aparium company website, [www.aparium.com](http://www.aparium.com), accessed April 25, 2017.
- Baker, Melissa A., Davis, Eric A., Weaver, Pamela A., "Eco-friendly Attitudes, Barriers to Participation, and Differences in Behavior at Green Hotels," *Cornell Hospitality Quarterly*, Vol. 55, 2014, pp. 89–99. Accessed March 3, 2017.
- Barbieri, Lyssandra D., LEED AP, "Green Building Data," Johns Hopkins University, Carey Business School, Edward St. John Department of Real Estate, April 23, 2008, accessed April 29, 2017.
- Barr, S., Shaw, G., & Coles, T., "Times for (un)sustainability? Challenges and opportunities for developing behaviour change policy. A case-study of consumers at home and away." *Global Environmental Change*, Vol. 21, 2011, pp. 1234–1244. Accessed April 21, 2017.
- Beachmeter.com, "Green Hotel Bookings Made Easy," [www.beachmeter.com](http://www.beachmeter.com), accessed May 12, 2017.
- Black, Rosemary, and Crabtree, Alice, "Quality Assurance and Certification in Ecotourism," CAB International, Wallingford Publishing, 2007, accessed May 11, 2017.
- Blinch, Jenny, McCarron, Benjamin, Yewdall, Katie, and Carmoody, Lucy, Editor, "Issues for Responsible Investors: The Future of Fish in Asia," Responsible Research, September 2011, accessed February 12, 2017.
- Bookdifferent.com, "Why should you book your hotel on BookDifferent?" [www.bookdifferent.com](http://www.bookdifferent.com), accessed May 16, 2017.
- Building Research Establishment, "BREEAM," BREAM website, <http://www.breeam.com/>, accessed March 29, 2017.
- Burrus, Daniel, "The Internet of Things is Far Bigger than Anyone Realizes," Burrus Research via Wired, November 2014, [www.wired.com](http://www.wired.com), accessed May 3, 2017.

- Center for Ecotourism and Sustainable Development, "A Simple User's Guide to Certification for Sustainable Tourism and Ecotourism," CESD Handbook #1, 3<sup>rd</sup> Edition, 2008, [www.ecotourismcesd.org](http://www.ecotourismcesd.org), accessed January 7, 2017.
- Chapla, Shannon, "Green Companies Earn More 'Green,' New Study Shows," University of Notre Dame News, March 26, 2012, accessed March 28, 2017.
- Chong, H. G., & Ricaurte, E. E., "Hotel sustainability benchmarking tool 2015: energy, water, and carbon," *Cornell Hospitality Reports*, Vol. 15, No. 9, 2015, pp. 6-11, accessed March 1, 2017.
- Chong, Howard, and Verma, Rohit, "Hotel Sustainability: Financial Analysis Shines a Cautious Green Light," Cornell Center for Hospitality Research, November 1, 2013, accessed March 16, 2017.
- Clean Energy Resource Teams, "Correction: A Room with a Viewpoint Revisited: Descriptive Norms and Hotel Guests' Towel Reuse Behavior," Public Library of Science ONE, August 20, 2014, accessed December 9, 2016.
- Crutzen, Paul J., and Stoermer, Eugene F., "The 'Anthropocene,'" International Geosphere-Biosphere Program, *Global Change Newsletter*, No. 41, May 2000, accessed April 20, 2017.
- Dobias, Jiri, and Macek, Daniel, "Leadership in Energy and Environmental Design (LEED) and its impact on building operational expenditures," Creative Construction Conference, 2014, accessed May 6, 2017.
- EcoStay, "The Program," EcoStay website, [www.ecostay.ca](http://www.ecostay.ca), accessed March 16, 2017.
- Eichholtz, Piet, Kok, Nils, and Quigley, John M., "Doing Well by Doing Good? Green Office Buildings," *The American Economic Review*, Vol. 100, No. 5, December 2010, pp. 2492-2509, accessed March 23, 2017.

- Esparon, Michelle, Gyuris, Emma, and Stoeckl, Natalie, "Does ECO certification deliver benefits? An empirical investigation of visitors' perceptions of the importance of ECO certification's attributes and of operators' performance." *Journal of Sustainable Tourism*, Vol. 22 No. 1, 2014. pp. 148-169, accessed April 19, 2017.
- Freireich, Jessica, and Fulton, Katherine, "Investing for Social and Environmental Impact," Monitor Institute, January 2009, accessed May 20, 2017.
- Gaztambide, José, "NBA 6380 Lecture – Quantified Ventures," Cornell University, April 18, 2016.
- Geerts, Wouter, "Environmental certification schemes: Hotel managers' views and perceptions," *International Journal of Hospitality Management*, Vol. 39, 2014, pp. 87-96, accessed April 19, 2017.
- Global Impact Investing Network, "What You Need to Know About Impact Investing," GIIN website, [www.thegiin.org](http://www.thegiin.org), accessed May 2, 2017.
- Goldstein, Kevin A., Primlani, Ritu Vasu, "Current Trends and Opportunities and Opportunities in Hotel Sustainability," HVS Sustainability Services, February 2012, accessed May 3, 2017.
- Green Building Alliance, "Green Building Certifications, Rating Systems, & Labels," Green Building Alliance website, [www.go-gba.org/resources/building-product-certifications/](http://www.go-gba.org/resources/building-product-certifications/), accessed January 7, 2017.
- Green Hotelier, "Sustainable Design," International Tourism Partnership Green Hotelier Newsletter, October 16, 2011, [www.greenhotelier.org](http://www.greenhotelier.org), accessed April 26, 2017.
- Green Traveler Guides, "TripAdvisor now ranking hotels as GreenLeaders," GTG Green Travel News, April 22, 2013, [www.greentravelerguides.com](http://www.greentravelerguides.com), accessed May 21, 2017.
- Greenwood, David A., "Culture, Environment, and Education in the Anthropocene: Assessing Schools for Generation R," Dordrecht: Springer Netherlands, 2014, pages 279-292.

GRESB, "2016 GRESB Snapshot," GRESB Real Estate Assessment, 2016, [www.gresb.com](http://www.gresb.com), accessed December 10, 2016.

Greshko, Michael, "First U.S. Bumblebee Officially Listed as Endangered," National Geographic, March 22, 2017, [news.nationalgeographic.com](http://news.nationalgeographic.com), accessed April 27, 2017.

Hagopian, Joachim "Death and Extinction of Bees," Global Research, March 24, 2017, [www.globalresearch.ca](http://www.globalresearch.ca), accessed May 11, 2017.

Hsiao, Teng-Yuan, Chuang, Chung-Ming, Kuo, Nae-Wen, and Yu, Sally Ming-Fong, "Establishing attributes of an environmental management system for green hotel evaluation," *International Journal of Hospitality Management*, Vol. 36, 2014, pp. 197-208, accessed March 16, 2017.

Hughes, Fran, "Hotels: Giant Leaps for Water Scarcity: China Water Risk," China Water Risk. December 15, 2015, accessed December 9, 2016.

InterContinental Hotel Group (IHG), "IGH Green Engage System," IGH website, [www.ihg.com/content/us/en/about/green-engage](http://www.ihg.com/content/us/en/about/green-engage), accessed May 22, 2017.

International Finance Corporation, "IFC Hotel Investments – Delivering Development Impact in Africa," The World Bank Group, 2011, [www.ifc.org](http://www.ifc.org), accessed May 1, 2017.

International Living Future Institute, "Living Building Challenge," ILFI website, [www.living-future.org/lbc/](http://www.living-future.org/lbc/), accessed March 29, 2017.

International Well Building Institute, "Our Standard," IWBI website, [www.wellcertified.com/en/our-standard](http://www.wellcertified.com/en/our-standard), accessed March 29, 2017.

Kang, Kyung Ho, Lee, Seoki, Huh, Chang, "Impacts of positive and negative corporate social responsibility activities on company performance in the hospitality industry," *International Journal of Hospitality Management*, Vol. 29, Issue 1, March 2010, pp 72-92, accessed May 3, 2017.

Kang, Kyung Ho, Stein, Laura, Heo, Cindy Yoonjoung, and Lee, Seoki, "Consumers' Willingness to Pay for Green Initiatives of the Hotel Industry," *International Journal of Hospitality Management*, Vol. 31, 2012, pp. 564-572, accessed March 16, 2017.

Kats, Gregory H., "Green Building Costs and Financial Benefits," Massachusetts Technology Collaborative, 2003, accessed April 27, 2016.

Kind Traveler, "About Us," [www.kindtravler.com](http://www.kindtravler.com), accessed May 16, 2017.

Knox, Nora, "Green Building Costs and Savings," United States Green Building Council Industry, March 25, 2015, accessed April 29, 2017.

Larceneux, Fabrice, Benoît-Moreau, Florence, and Parguel, Béatrice, "How Sustainability Ratings Might Deter "Greenwashing": A Closer Look at Ethical Corporate Communication," *Journal of Business Ethics*, Vol. 102, No. 1, 2011, pp 15-28, accessed May 16, 2017.

Langdon, Davis, "Cost of Green Revisited: Reexamining the Feasibility and Cost Impact of Sustainable Design in the Light of Increased Market Adoption," July 2007, Retrieved from Smart Energy Design Assistance Center, accessed April 29, 2017.

Lee, Seoki, and Heo, Cindy Yoonjoung, "Corporate social responsibility and customer satisfaction among US publicly traded hotels and restaurants," *International Journal of Hospitality Management*, Vol. 28, 2009, pp. 635-637, accessed May 1, 2017.

Lewis, Sally Anne, "Are We in the Anthropocene Yet?" Decoded Science, May 19, 2011, [www.decodedscience.org](http://www.decodedscience.org), accessed April 26, 2017.

Long, Marisa, "LEED v4, the Newest Version of LEED Green Building Program Launches at USGBC's Annual Greenbuild Conference," United States Green Building Council Media, November 20, 2013, accessed March 14, 2017.

Los Angeles Better Buildings Challenge, "Green Buildings Thriving in LA Real Estate Market, According to CoStar Report." US Department of Energy, August 6, 2014. Accessed May 1, 2017.

- Manaktola, K., and Jauhari, V. "Exploring consumer attitude and behaviour towards green practices in the lodging industry in India," *International Journal of Contemporary Hospitality Management*, Vol. 19, Issue 5, 2007, pp. 364–377, accessed March 16, 2017.
- Mark, Laura, "LEED Outstrips BREEAM Across the Globe – Including Europe," *The Architect's Journal*, February 28, 2013, [www.architectsjournal.co.uk](http://www.architectsjournal.co.uk), accessed April 22, 2017.
- Marr, Bernard, "How Big Data and Analytics Are Changing Hotels and The Hospitality Industry," *Forbes.com*, January 26, 2016, accessed May 1, 2017.
- McDonald, Robert, "Water on an Urban Planet: Urbanization and the Reach of Urban Water Infrastructure," *Global Environmental Change* Vol. 27, July 2014, pp 96-105, accessed December 9, 2016.
- McGraw Hill Construction, "World Green Building Trends 2013: Business Benefits Driving New and Retrofit Market Opportunity in Over 60 Countries," McGraw Hill Construction SmartMarket Report, 2013, [www.gbcsa.org](http://www.gbcsa.org), accessed May 3, 2017.
- McGraw Hill Construction, "Green Outlook 2011: Green Trends Driving Growth," McGraw Hill Construction Industry Forecast and Trends, 2011, accessed March 28, 2017.
- Mest, Elliot, "Why Hotels Should Consider Beekeeping," *Hotel Management*, May 22, 2016, [www.hotelmanagement.net](http://www.hotelmanagement.net), accessed April 27, 2017.
- Miao, L., & Wei, W., "Consumers' pro-environmental behavior and the underlying motivations: A comparison between household and hotel settings," *International Journal of Hospitality Management*, Vol. 32, 2013, pp. 102–112, accessed April 21, 2017.
- Mukerjee, Matt, "Bee Informed," Bee Control of Pittsburgh & American Beekeeping Federation, July 25, 2014, [www.abfnet.org](http://www.abfnet.org), accessed May 11, 2017.
- Newsham, Guy R., Mancini, Sandra, and Birt, Benjamin J., "Do LEED-Certified Buildings Save Energy? Yes, but...," National Research Council for Canada – Institute for Research in Construction, August 2009, accessed May 16, 2017.

Nyikos, David M., Thal, Alfred E., Hicks, Michael J., and Leach, Sonia E, "To LEED or Not to LEED: Analysis of Cost Premiums Associated with Sustainable Facility Design," *Engineering Management Journal*, Vol. 24, Issue 4, 2012, pp. 50-62, accessed March 16, 2017.

Ogden, Laura, Heynen, Nik, Oslender, Ulrich, West Paige, Kassam, Karim-Aly, and Robbins, Paul, "Global Assemblages, Resilience, and Earth Stewardship in the Anthropocene," *Frontiers in Ecology and the Environment*, Vol. 11 Issue 7, September 2013. Accessed May 1, 2017.

O'Neil & Siegelbaum, The RICE Group, "Hotel Water Conservation: A Seattle Demonstration," Seattle Public Utilities Resource Conservation Section, July 2002, accessed April 24, 2017.

Ongreening Team, "LEED Rating System: 5-minute Guide," Ongreening, [www.ongreening.com](http://www.ongreening.com), accessed May 20, 2017.

Owens, Brendan, Macken, Chrissy, Rohloff, Adam, and Rosenberg, Heather, "LEED v4 Impact Category and Point Allocation Development Process," United States Green Building Council, Altura Associates, The Cadmus Group, 2017, accessed March 13, 2017.

PSFK Labs, "Why Crowdsourced Hotel Design Will Be the Future of Business Travel," PSFK, February 4, 2014, accessed March 16, 2017.

Rahman, Imran, Park, Jeongdoo, and Chi, Christina Geng-qing, "Consequences of "greenwashing": Consumers' reactions to hotels' green initiatives," *International Journal of Contemporary Hospitality Management*, Vol. 27 Issue: 6, 2015, pp.1054-1081, accessed May 12, 2017.

Raschke, Steve, "Costs, Savings, and ROI for Smart Building Implementation," IoT@Intel Blog, June 20, 2016, [blogs.intel.com/iot](http://blogs.intel.com/iot), accessed February 20, 2017.

Redefine International, "Corporate Social Responsibility 2016," Redefine International P.L.C., 2016, accessed May 20, 2017.

Robinson, Spenser J., and Das, Prashant Kumar, "Financial Impact of LEED and EnergyStar Certifications on Hotel Revenues," *Journal of Hospitality Financial Management*, Vol. 24, Issue 2, 2016, pp. 110-126, accessed March 16, 2017.

- Rogers, Peter, "Facing the Freshwater Crisis," *Scientific American*, No. 299, August 2008, pp. 46-53, accessed December 9, 2016.
- Rogers, Reese. "Reusing Hotel Towels: Nitty-gritty," *Stanford Magazine*, 2010, accessed December 9, 2016.
- Sandoval-Strauz, A. K., *Hotel: An American History*, 2007.
- Segarra-Oña, M., Peiro-Signes, A., Verma, R., Mondejar-Jimenez, J., & Vargas-Vargas, M., "Environmental management certification (ISO 14001): Effects on hotel guest reviews," *Cornell Hospitality Report*, Vol. 14, Issue 8, 2014, pp 6-17, accessed March 16, 2017.
- Senseware, "Commercial Building Water Efficiency Management," [www.senseware.co](http://www.senseware.co), accessed February 20, 2017.
- Scofield, J. H., "Do LEED-Certified Buildings Save Energy? Not Really...," *Energy and Buildings*, Vol. 41, Issue 12, 2009, p. 1386-1390, accessed May 16, 2017.
- Smalling, Lindsay, and Emerson, Jed, "Understanding Impact: The Current and Future State of Impact Investing Research," *ImpactAssets Issue Brief No. 14*, 2015, [www.impactassets.org](http://www.impactassets.org), accessed May 1, 2017.
- Spencer, Michael R., "The ASPEN Design Tool: A LEED Credit Design and Cost Minimization Program," *The University of Texas at Austin College of Architecture*, May 2012, accessed May 6, 2017.
- Terry, Hannah, "Financing the Big Society: Why Social Investment Matters," *Charities Aid Foundation*, September 2010, accessed May 20, 2017.
- The World Bank, "Thirsty Energy: Securing Energy in a Water-Constrained World," *World Bank Group*, 2016, accessed December 9, 2016.
- Thompson, Emily, "Urban Beekeeping Is Trending in Columbus," *Columbus Monthly*, May 13, 2015, [www.columbusmonthly.com](http://www.columbusmonthly.com), accessed April 26, 2017.

TripAdvisor, "GreenLeaders," TripAdvisor website, [www.tripadvisor.com/GreenLeaders](http://www.tripadvisor.com/GreenLeaders) accessed May 21, 2017.

Tuppen, Holly, "Water Management and Responsibility in Hotels" International Tourism Partnership Green Hotelier: Sustainable Management of Water, March 2013, accessed December 9, 2016.

United Nations, "Sustainable Development Goals – United Nations," United Nations official website, [www.un.org/sustainabledevelopment](http://www.un.org/sustainabledevelopment), accessed April 20, 2017.

United Nations, "United Nations Millennium Development Goals," United Nations official website, [www.un.org/millenniumgoals](http://www.un.org/millenniumgoals), accessed April 20, 2017.

United Nations, "Water and Urbanization Media Brief," UN Water Decade Programme on Advocacy and Communication, 2010, accessed December 9, 2016.

United Nations Department of Economic and Social Affairs, Population Division, "World Urbanization Prospects: The 2014 Revision, Highlights," United Nations, 2014, [www.esa.un.org](http://www.esa.un.org), accessed April 16, 2017.

United Nations, "Water and Cities," [www.un.org](http://www.un.org), accessed February 9, 2017.

United States Department of Agriculture, "Declining honeybees a 'threat' to food supply," NBC News via Associated Press, May 2, 2007, [www.nbcnews.com](http://www.nbcnews.com), accessed May 11, 2017.

United States Department of Labor, "Employment by Major Industry Sector," USDL Bureau of Labor Statistics Public Data, [www.bls.gov](http://www.bls.gov), accessed May 1, 2017.

United States Environmental Protection Agency, "ENERGY STAR Certification," US EPA Energy Star website, [www.energystar.gov/buildings/about-us/energy-star-certification](http://www.energystar.gov/buildings/about-us/energy-star-certification), accessed March 29, 2017.

United States Environmental Protection Agency, "Saving Water in Hotels," EPA WaterSense H20tel Challenge, 2015, accessed December 9, 2016.

United States Environmental Protection Agency, “Water Use Tracking,” Energy Star Portfolio Manager DataTrends, October 2012, accessed December 9, 2016.

United States Fish and Wildlife Service, “Fact Sheet – Rusty Patched Bumble Bee,” USFW government website, [www.fws.gov](http://www.fws.gov), accessed April 25, 2017.

United States Geological Survey, “Water Use in the United States,” USGS Water Use in the United States County Data, 2010, [www.usgs.gov](http://www.usgs.gov), accessed December 9, 2016.

United States Green Building Council, “About LEED,” USGBC website, [www.usgbc.org/articles/about-leed](http://www.usgbc.org/articles/about-leed), accessed March 13, 2017.

United States Green Building Council, “Good to Known: Green Building Incentive Strategies,” USGBC website, May 2, 2014, [www.usgbc.org/articles](http://www.usgbc.org/articles), accessed March 28, 2017.

United States Green Building Council, “LEED – Better Buildings are our Legacy,” USGBC website, [www.usgbc.org/leed](http://www.usgbc.org/leed), accessed May 8, 2017.

United States Green Building Council, “LEED Certification Fees,” USGBC website, [www.usgbc.org/cert-guide/fees](http://www.usgbc.org/cert-guide/fees), accessed February 26, 2017.

United States Green Building Council, “LEED in Motion: Hospitality,” USGBC via Readymag, January 20, 2016, [www.readymag.com/usgbc/hospitality/](http://www.readymag.com/usgbc/hospitality/), accessed March 16, 2017.

United States Green Building Council, “LEED v4,” USGBC website, [www.usgbc.org/leed-v4](http://www.usgbc.org/leed-v4), accessed March 13, 2017.

United States Green Building Council, “Public LEED Project Directory,” USGBC website, [www.usgbc.org/projects](http://www.usgbc.org/projects), accessed March 13, 2017.

United States Green Building Council, “USGBC Statistics,” USGBC Media, July 1, 2016, [www.usgbc.org/articles/usgbc-statistics](http://www.usgbc.org/articles/usgbc-statistics), accessed May 1, 2017.

United States Green Building Council, "What are Regional Priority (RP) Credits?" USGBC Help Search, [www.usgbc.org/help](http://www.usgbc.org/help), accessed March 20, 2017.

United States Green Building Council, "What is Green Building?" YouTube, October 16, 2015, accessed April 18, 2017.

United States Green Building Council, "What is WELL?" USGBC website, [www.usgbc.org/articles/what-well](http://www.usgbc.org/articles/what-well), accessed April 22, 2017.

University of California Museum of Paleontology, "The Holocene Epoch," University of California Museum of Paleontology website, [www.ucmp.berkeley.edu](http://www.ucmp.berkeley.edu), accessed April 20, 2017.

Urban Bees FAQ, "Helping Bees in the City," Urban Bees, 2017, [www.urbanbees.co.uk](http://www.urbanbees.co.uk), accessed May 10, 2017.

Van Oostrom, Coen, "Smart Cities: How Technology Will Change Our Buildings," YouTube, TEDx Berlin, October 28, 2016, accessed December 9, 2016.

Walsman, M., Verma, R., and Muthulingam, S., "The Impact of LEED certification on hotel performance," Cornell Hospitality Report, Vol. 14, 2014, pp. 6-13, accessed Jan 26, 2017.

Weeks, Katie, "Ohio Senators Propose LEED Ban," EcoBuilding Pulse, November 8, 2013, [www.ecobuildingpulse.com](http://www.ecobuildingpulse.com), accessed May 20, 2017.

Willard, Bob, "3 Sustainability Models," Sustainability Advantage, July 20, 2010, [www.sustainabilityadvantage.com](http://www.sustainabilityadvantage.com), accessed May 10, 2017.

Wood, Maria. "How Green is My Hotel?" The Wayward Post Travel Guide, March 2, 2016. [www.waywardpost.com/stories](http://www.waywardpost.com/stories), accessed May 20, 2017.

World Commission on Environment and Development, *Our Common Future*, 1987, Oxford, Oxford University Press.

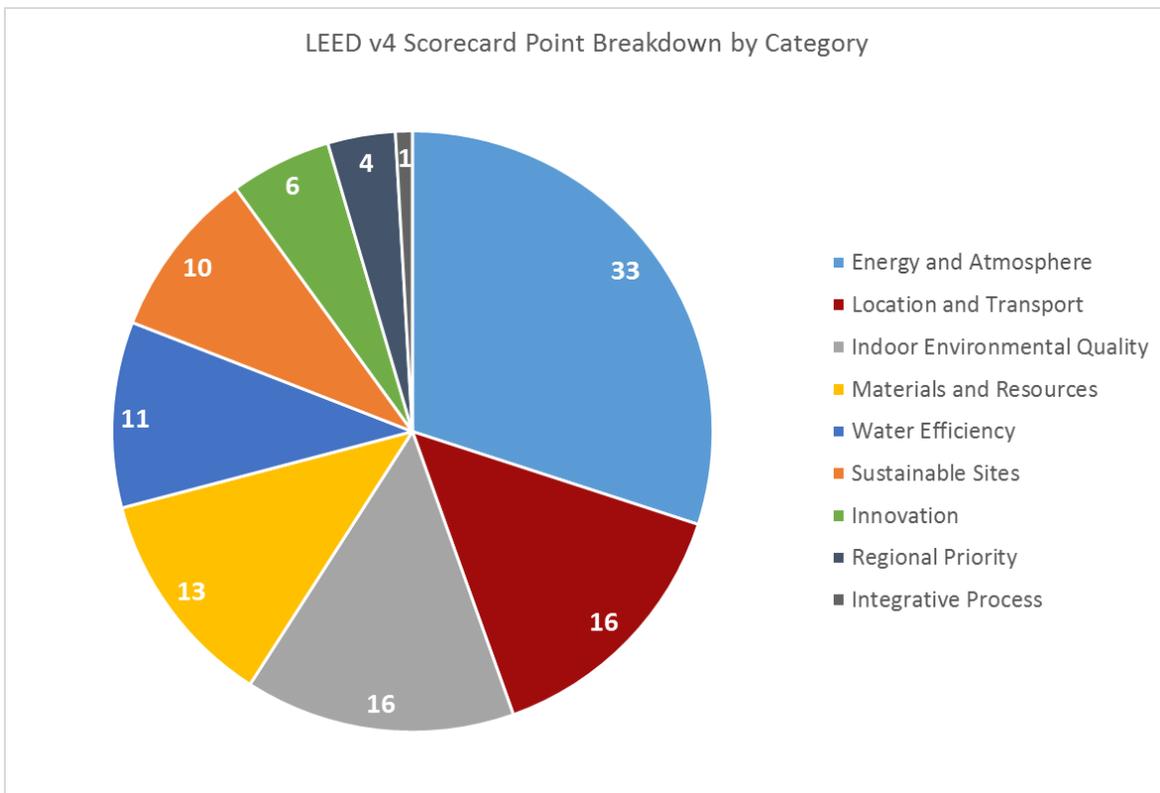
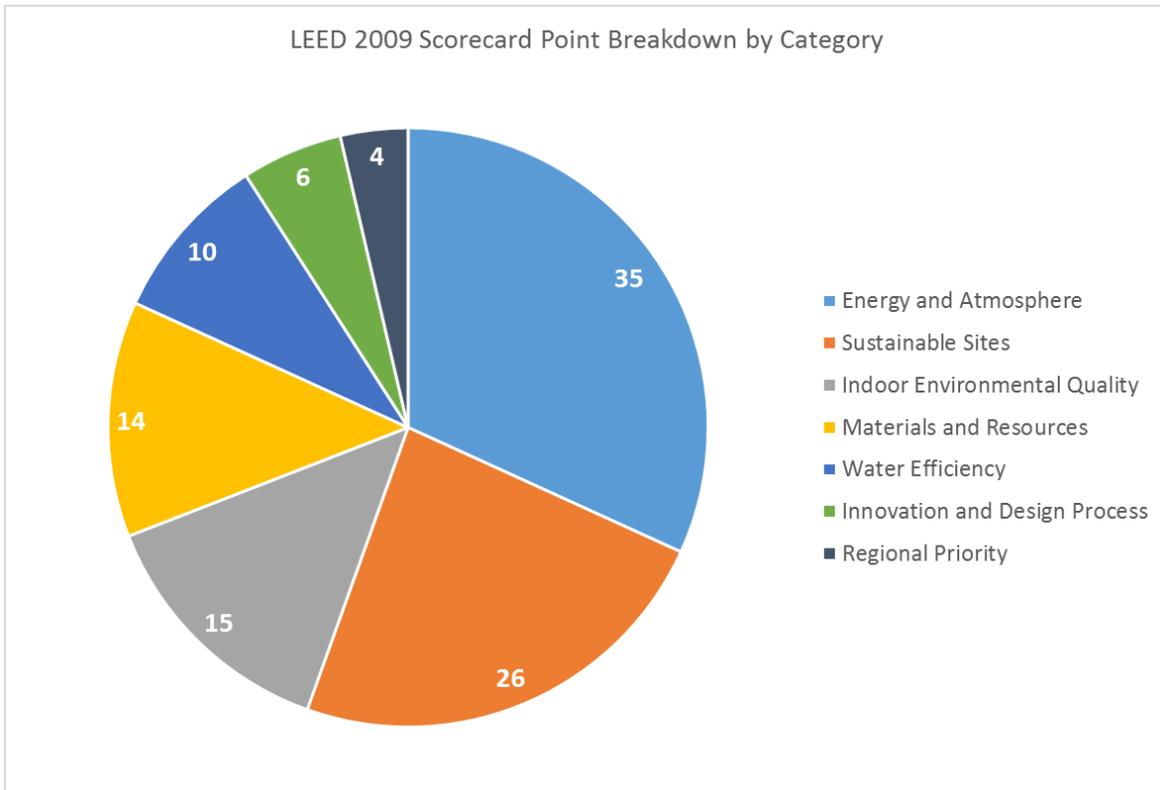
World Health Organization, "Water and Cities," United Nations and World Health Organization, 2014, accessed December 9, 2016.

## LIST OF APPENDICES

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## Appendix A: LEED Scorecard Category Breakdowns



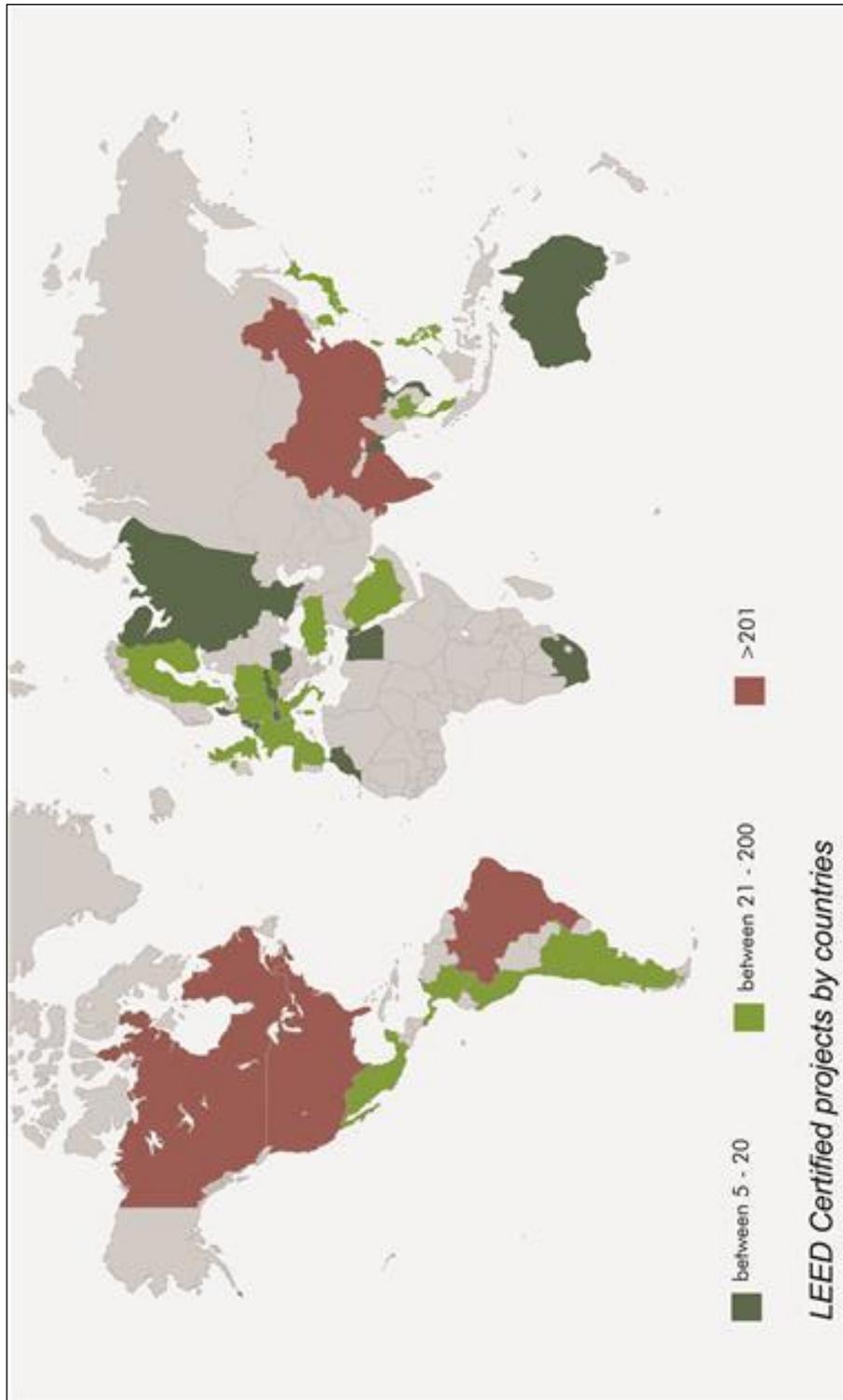
Source: USGBC 2017

# Appendix B: LEED Scorecard Example

| Y  |    | ?      |   | N |   | Credit                                     |   | Integrative Process |   | 1 |    |
|--|----|--------|---|---|---|--|---|---------------------|---|---|----|
| <p><b>LEED v4 for BD+C: New Construction and Major Renovation</b><br/>Project Checklist</p> <p>Project Name: _____<br/>Date: _____</p> |    |        |   |   |   |  |   |                     |   |   |    |
| <p><b>0 0 0 0 Location and Transportation</b></p>  |    |        |   |   |   | <p><b>Materials and Resources</b></p>      |   |                     |   |   |    |
| Credit   | 16 | Prereq | 0 | 0 | 0 | Prereq                                     | 0 | 0                   | 0 | 0 | 13 |
| Credit   | 1  | Prereq | 0 | 0 | 0 | Prereq                                     | 0 | 0                   | 0 | 0 | 5  |
| Credit   | 2  | Credit | 0 | 0 | 0 | Credit                                     | 0 | 0                   | 0 | 0 | 2  |
| Credit   | 5  | Credit | 0 | 0 | 0 | Credit                                     | 0 | 0                   | 0 | 0 | 2  |
| Credit   | 5  | Credit | 0 | 0 | 0 | Credit                                     | 0 | 0                   | 0 | 0 | 2  |
| Credit   | 1  | Credit | 0 | 0 | 0 | Credit                                     | 0 | 0                   | 0 | 0 | 2  |
| Credit   | 1  | Credit | 0 | 0 | 0 | Credit                                     | 0 | 0                   | 0 | 0 | 2  |
| Credit   | 1  | Credit | 0 | 0 | 0 | Credit                                     | 0 | 0                   | 0 | 0 | 2  |
| <p><b>0 0 0 0 Sustainable Sites</b></p>  |    |        |   |   |   | <p><b>Indoor Environmental Quality</b></p> |   |                     |   |   |    |
| Prereq   | 10 | Prereq | 0 | 0 | 0 | Prereq                                     | 0 | 0                   | 0 | 0 | 16 |
| Credit   | 1  | Prereq | 0 | 0 | 0 | Prereq                                     | 0 | 0                   | 0 | 0 | 2  |
| Credit   | 2  | Credit | 0 | 0 | 0 | Credit                                     | 0 | 0                   | 0 | 0 | 3  |
| Credit   | 1  | Credit | 0 | 0 | 0 | Credit                                     | 0 | 0                   | 0 | 0 | 1  |
| Credit   | 3  | Credit | 0 | 0 | 0 | Credit                                     | 0 | 0                   | 0 | 0 | 2  |
| Credit   | 2  | Credit | 0 | 0 | 0 | Credit                                     | 0 | 0                   | 0 | 0 | 1  |
| Credit   | 1  | Credit | 0 | 0 | 0 | Credit                                     | 0 | 0                   | 0 | 0 | 2  |
| <p><b>0 0 0 0 Water Efficiency</b></p>   |    |        |   |   |   | <p><b>Innovation</b></p>                   |   |                     |   |   |    |
| Prereq   | 11 | Prereq | 0 | 0 | 0 | Prereq                                     | 0 | 0                   | 0 | 0 | 6  |
| Prereq   | 2  | Credit | 0 | 0 | 0 | Credit                                     | 0 | 0                   | 0 | 0 | 5  |
| Prereq   | 6  | Credit | 0 | 0 | 0 | Credit                                     | 0 | 0                   | 0 | 0 | 1  |
| Credit   | 2  | Credit | 0 | 0 | 0 | Credit                                     | 0 | 0                   | 0 | 0 | 1  |
| Credit   | 1  | Credit | 0 | 0 | 0 | Credit                                     | 0 | 0                   | 0 | 0 | 4  |
| <p><b>0 0 0 0 Energy and Atmosphere</b></p>  |    |        |   |   |   | <p><b>Regional Priority</b></p>            |   |                     |   |   |    |
| Prereq   | 33 | Prereq | 0 | 0 | 0 | Prereq                                     | 0 | 0                   | 0 | 0 | 1  |
| Prereq   | 6  | Credit | 0 | 0 | 0 | Credit                                     | 0 | 0                   | 0 | 0 | 1  |
| Prereq   | 18 | Credit | 0 | 0 | 0 | Credit                                     | 0 | 0                   | 0 | 0 | 1  |
| Prereq   | 1  | Credit | 0 | 0 | 0 | Credit                                     | 0 | 0                   | 0 | 0 | 1  |
| Prereq   | 2  | Credit | 0 | 0 | 0 | Credit                                     | 0 | 0                   | 0 | 0 | 1  |
| Prereq   | 3  | Credit | 0 | 0 | 0 | Credit                                     | 0 | 0                   | 0 | 0 | 1  |
| Prereq   | 1  | Credit | 0 | 0 | 0 | Credit                                     | 0 | 0                   | 0 | 0 | 1  |
| Prereq   | 2  | Credit | 0 | 0 | 0 | Credit                                     | 0 | 0                   | 0 | 0 | 1  |
| <p><b>0 0 0 0 TOTALS</b></p>   |    |        |   |   |   | <p><b>0 0 0 0 TOTALS</b></p>               |   |                     |   |   |    |
| <p>Required 110</p>  |    |        |   |   |   | <p>Required 110</p>                        |   |                     |   |   |    |
| <p>Certified: 40 to 49 points, Silver: 50 to 59 points, Gold: 60 to 79 points, Platinum: 80 to 110</p>                                 |    |        |   |   |   |  |   |                     |   |   |    |

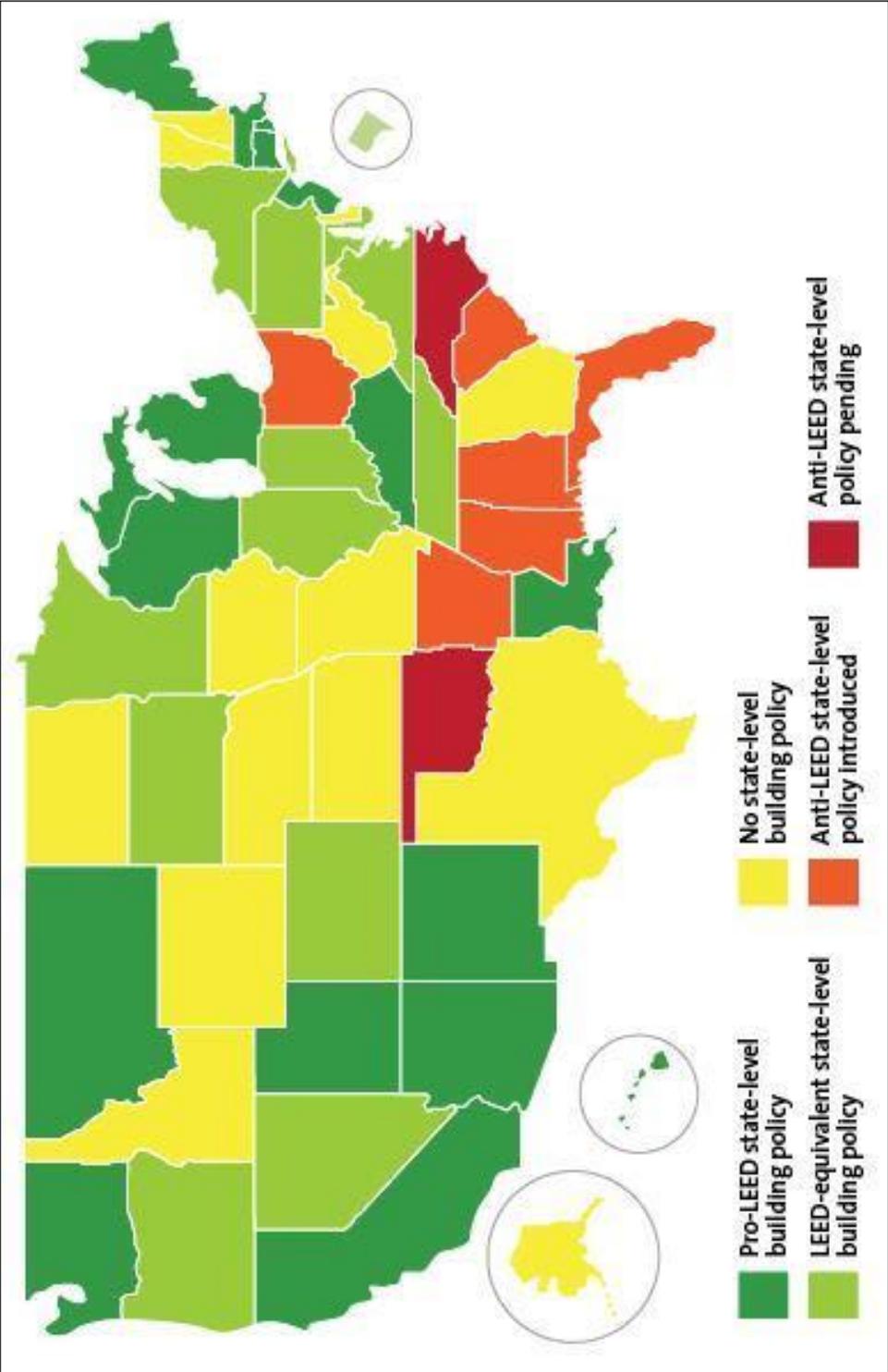
Source: USGBC (2017)

## Appendix C: LEED Projects by Country



Source: Ongreening Team (2017)

**Appendix D: State Government Treatment of LEED Certification**



Source: EcoBuilding (2013)

## Appendix E: LEED Certification Linear Programming Model Objective Function

### Objective Function = Minimize Costs

$$\sum_{j=1}^n \text{Cost}_i \text{Project}_i$$

*Cost = Measured Costs of Each Project*

*Project = 1 or 0 (hotel can choose to pursue project or not)*

*Coefficient = Number of Credits*

*Subject to...*

*Total Credits  $\geq$  Minimum Credits for Desired Certification Level*

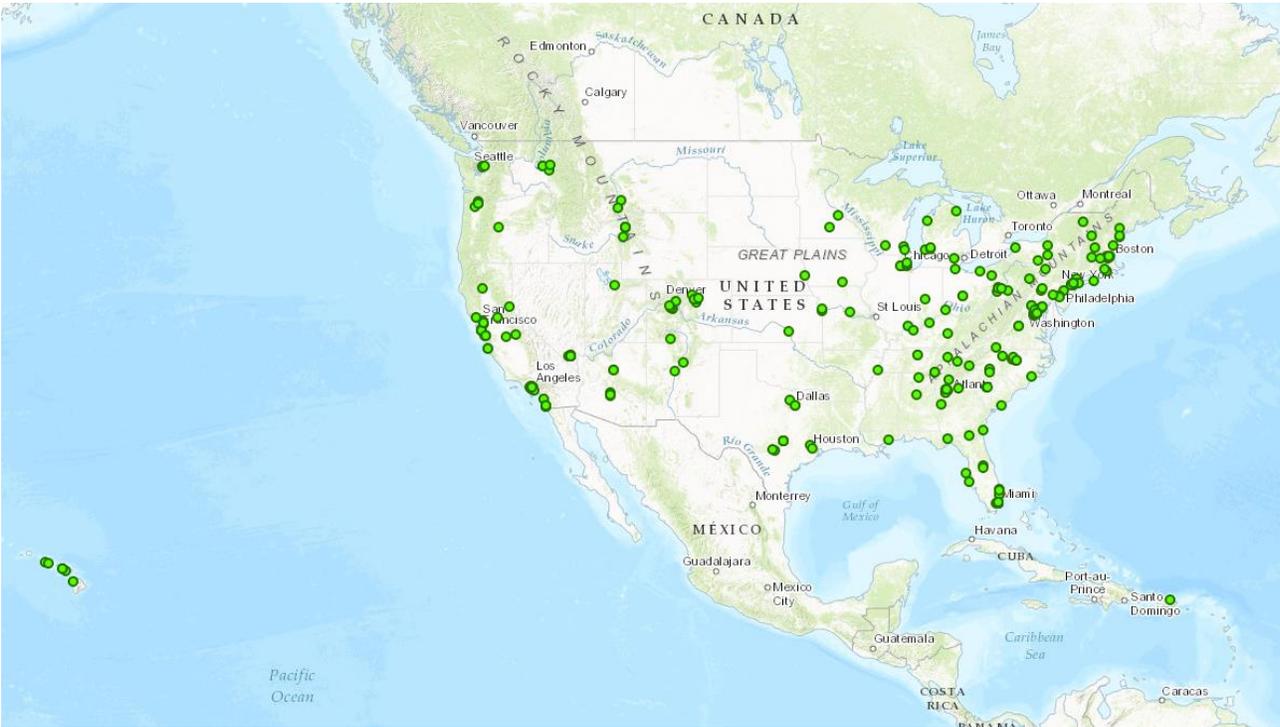
*Total Costs  $\leq$  Hotel Construction LEED Budget*

*All Required LEED credits met*

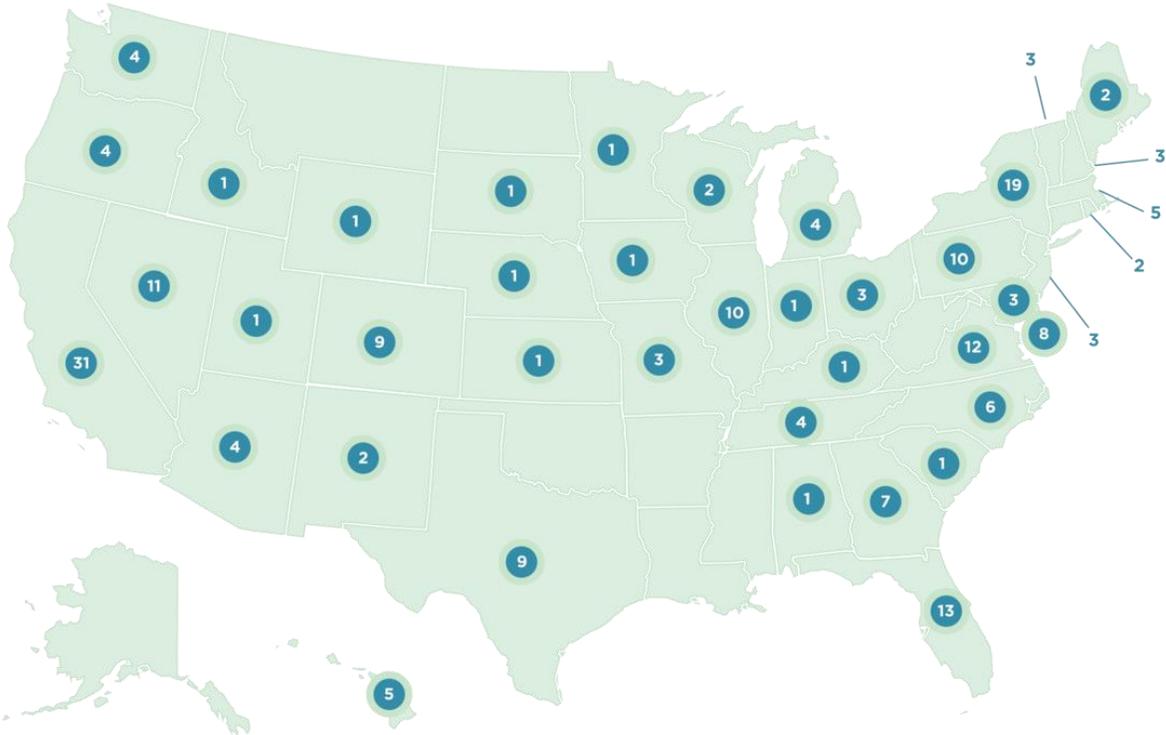
*All Categories  $\geq 0$*

*Source: Michael Spencer ASPEN Tool (2012)*

**APPENDIX F: Locations and Counts of LEED Certified Hotels in the United States**

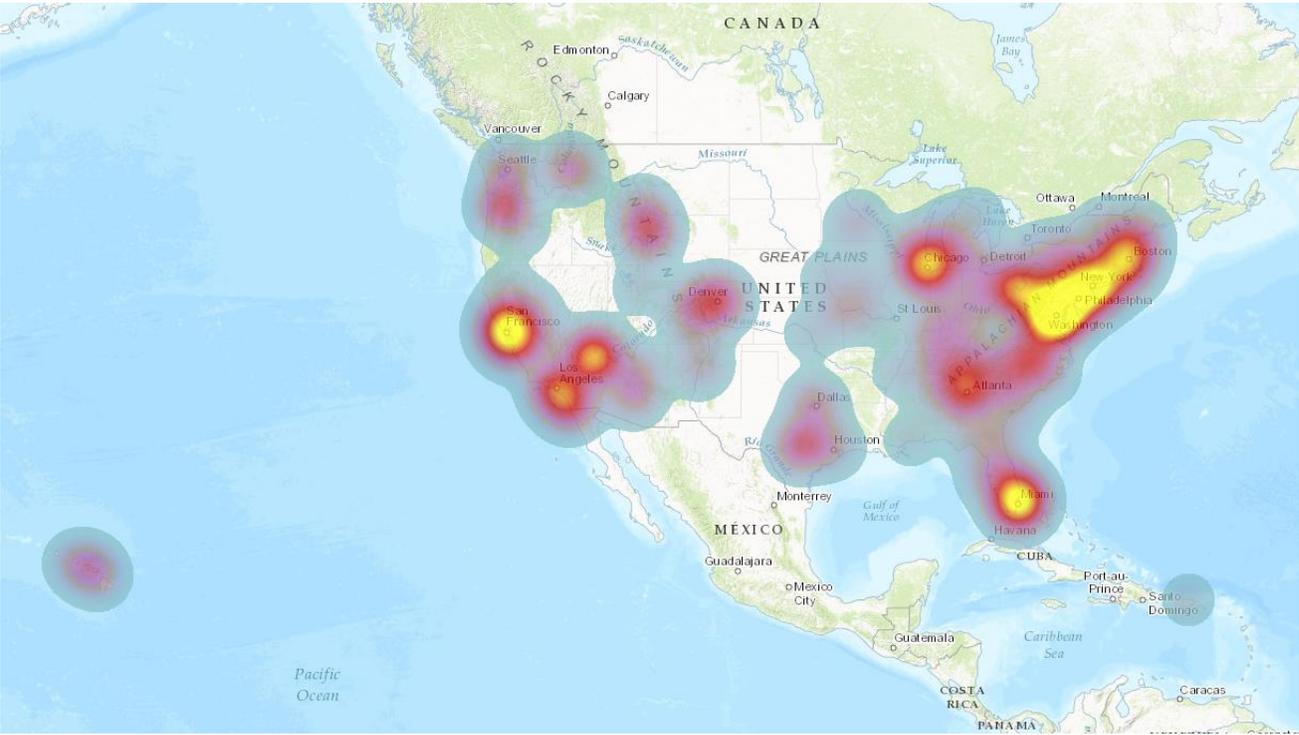


Source: USGBC 2017, Custom ArcGIS Layer

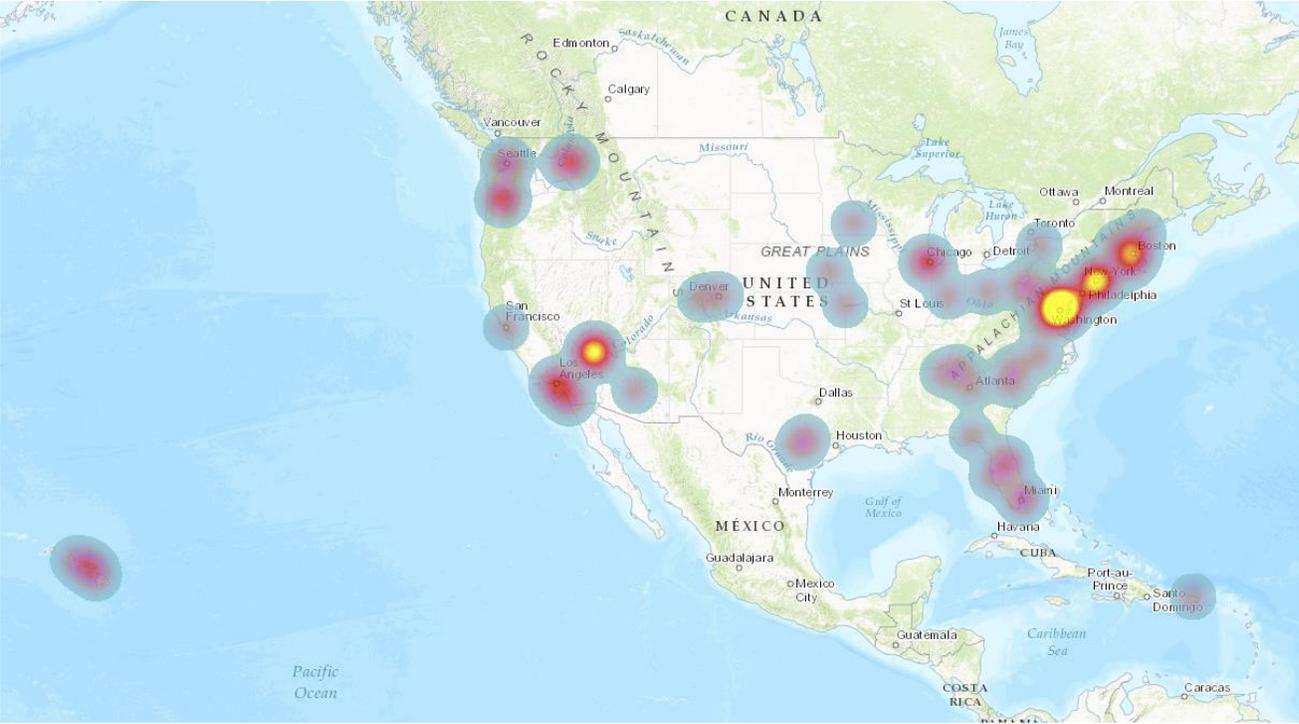


Source: USGBC "LEED in Motion" (2016)

**Appendix G: All LEED Hotel Sites Heatmap vs. CHSB Sample LEED Hotel Sites Heatmap**

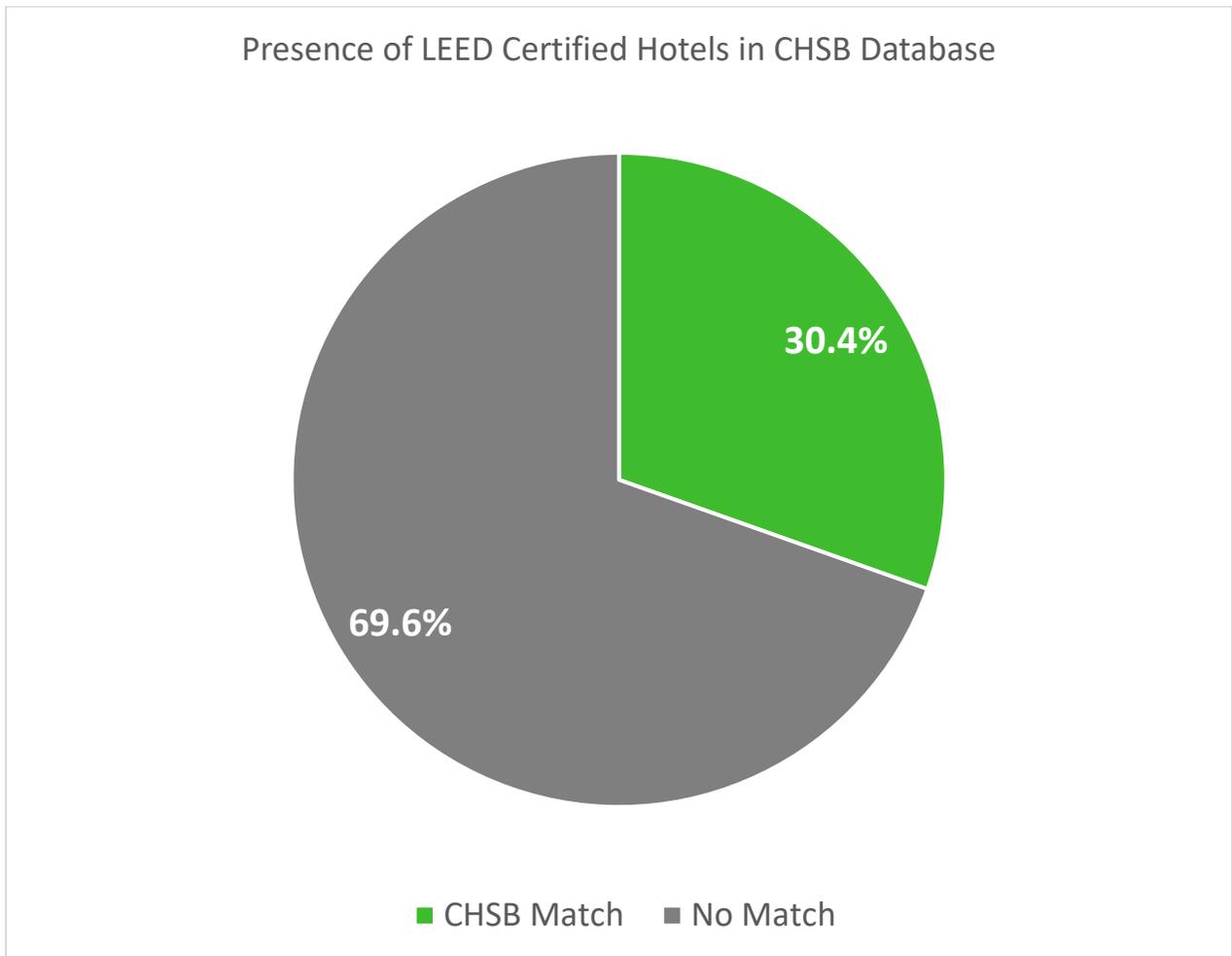


Source: USGBC 2017, Custom ArcGIS Layer



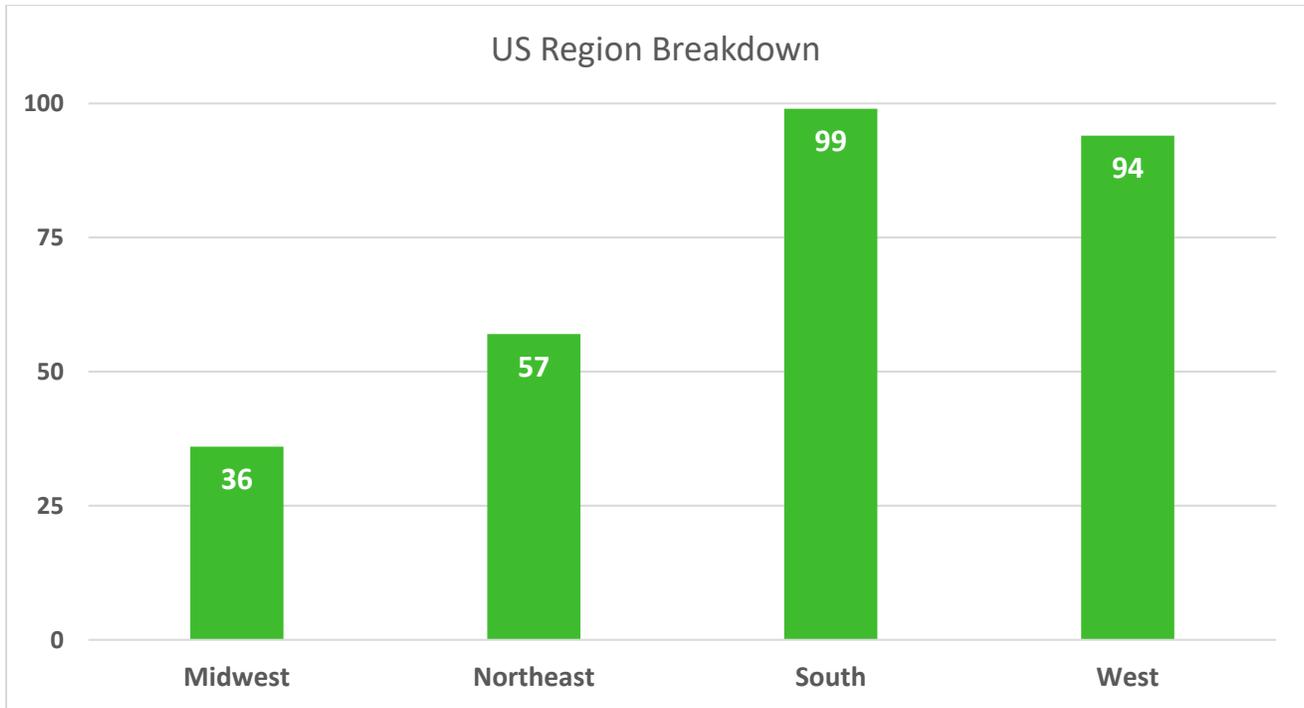
Source: USGBC 2017, Cornell Hospitality Sustainability Benchmarking Tool, Customer ArcGIS Layer

## Appendix H: Percentage of LEED Hotels Matched to CHSB Database

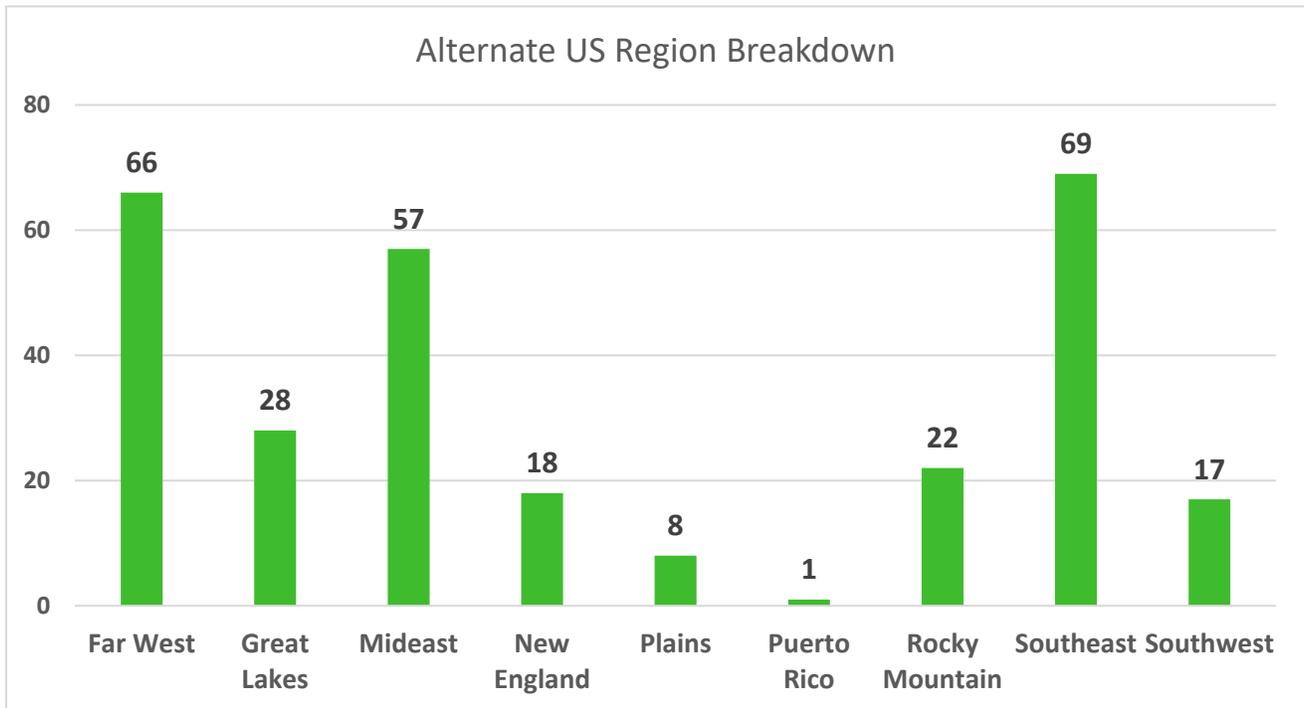


Source: USGBC 2017, Cornell Hospitality Sustainability Benchmarking Tool 2015

## Appendix I: Geographic Breakdown of LEED Hotels in United States

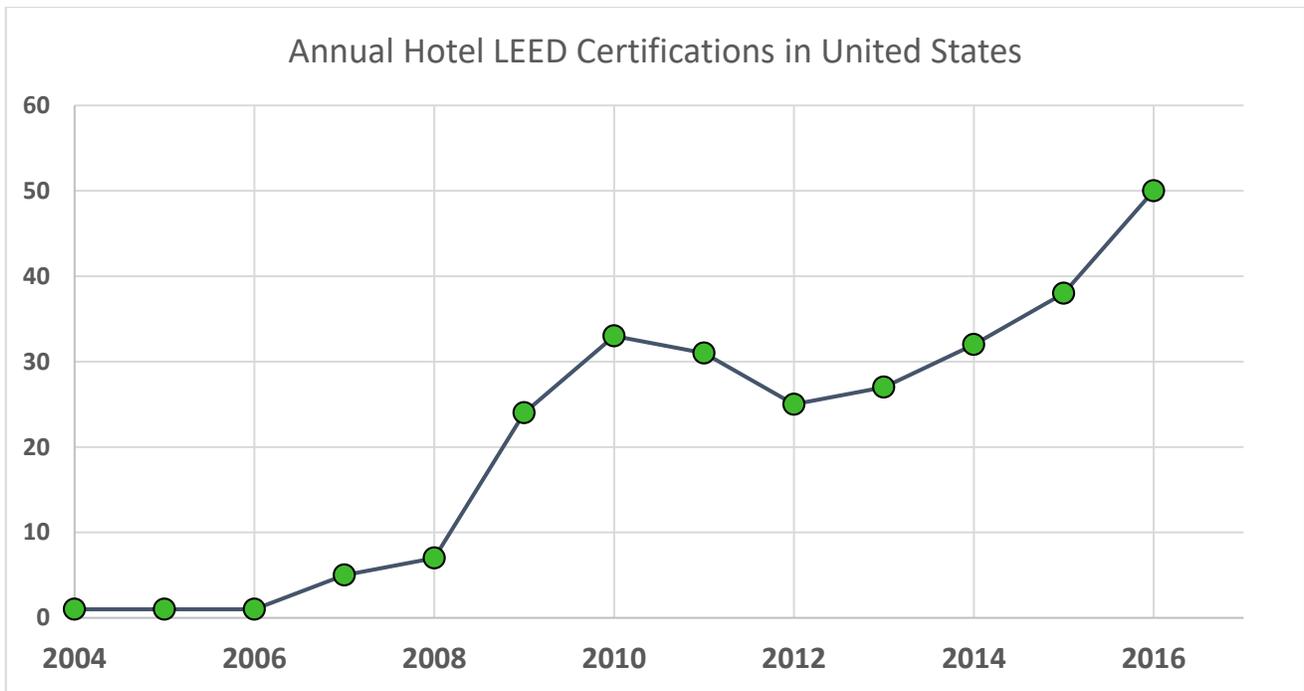


Source: USGBC 2017, Regions based on US Census Bureau

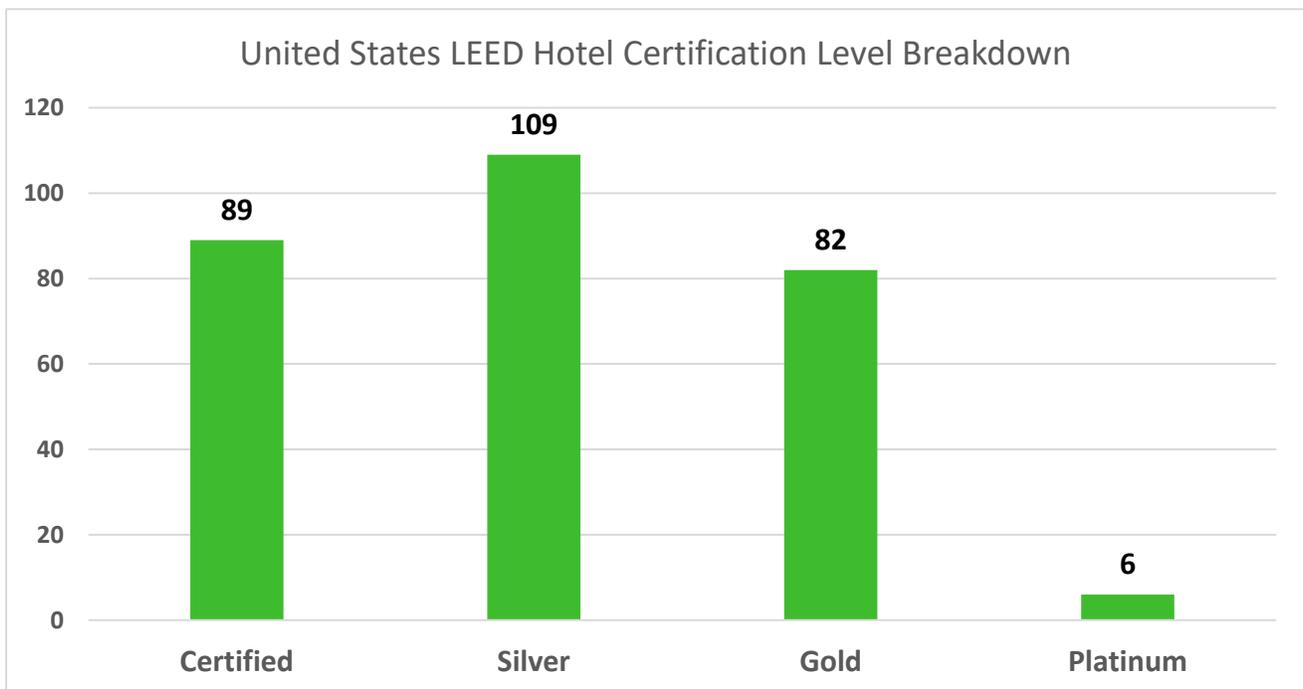


Source: USGBC 2017, Regions based on US Bureau of Economic Analysis

## Appendix J: LEED Hotel Data Breakdown



Source: USGBC 2017



Source: USGBC 2017

## Appendix K: Descriptive Statistics for 2015 CHSB Data for All Sustainability Metrics

| Descriptive Stats on Carbon Footprint per OCRM |      |           |        |      |       |       |
|--|------|-----------|--------|------|-------|-------|
|  | Mean | Std. Dev. | Median | Min  | Max   | Count |
| All Properties                                 | 25.2 | 20.5      | 19.5   | 3.5  | 330.9 | 2,037 |
| LEED Certified                                 | 28.9 | 28.0      | 20.3   | -    | 184.2 | 54    |
| Non-LEED Certified                             | 25.1 | 20.3      | 19.5   | 3.5  | 330.9 | 1,983 |
| Full Service                                   | 36.5 | 23.3      | 31.2   | -    | 184.2 | 562   |
| Limited Service                                | 20.6 | 17.0      | 17.2   | 3.5  | 330.9 | 1,436 |
| Luxury   | 50.0 | 31.3      | 44.7   | 12.6 | 180.7 | 120   |
| Upper Upscale                                  | 32.7 | 20.5      | 28.8   | -    | 184.2 | 455   |
| Upscale  | 19.2 | 8.8       | 17.4   | 6.4  | 103.8 | 804   |
| Upper Midscale                                 | 22.9 | 24.2      | 17.3   | 3.5  | 330.9 | 567   |
| Midscale                                       | 16.5 | 12.8      | 12.0   | 6.1  | 72.4  | 67    |
| Economy  | 42.8 | #DIV/0!   | 42.8   | 42.8 | 42.8  | 1     |
| 5 Stars  | 61.2 | 24.0      | 52.0   | 13.9 | 180.7 | 49    |
| 4 Stars  | 35.4 | 18.6      | 29.4   | -    | 184.2 | 314   |
| 3 Stars  | 22.2 | 20.9      | 18.7   | 5.9  | 185.1 | 1,198 |
| 2 Stars  | 20.5 | 19.9      | 15.5   | 3.5  | 330.9 | 430   |
| Tropical                                       | 27.3 | 20.0      | 20.6   | 9.3  | 142.4 | 69    |
| Arid   | 19.9 | 13.0      | 16.0   | 6.8  | 101.4 | 161   |
| Temperate                                      | 24.8 | 20.4      | 19.3   | -    | 330.9 | 1,535 |
| Cold (Continental)                             | 29.7 | 23.6      | 22.9   | 6.1  | 204.4 | 272   |
| Laundry Inc.                                   | 24.7 | 20.7      | 19.0   | 3.5  | 330.9 | 1,533 |
| Laundry Not Inc.                               | 25.7 | 16.7      | 20.1   | 5.1  | 117.7 | 354   |

| Descriptive Stats on Carbon Footprint per Sq. M. |       |           |        |      |       |       |
|--|-------|-----------|--------|------|-------|-------|
|  | Mean  | Std. Dev. | Median | Min  | Max   | Count |
| All Properties                                   | 100.2 | 52.9      | 88.8   | 17.2 | 543.8 | 2,049 |
| LEED Certified                                   | 97.8  | 48.9      | 88.0   | 29.5 | 336.0 | 58    |
| Non-LEED Certified                               | 100.2 | 53.0      | 88.8   | 17.2 | 543.8 | 1,991 |
| Full Service                                     | 118.7 | 56.0      | 109.3  | 26.5 | 500.9 | 594   |
| Limited Service                                  | 93.4  | 49.9      | 82.1   | 17.2 | 543.8 | 1,373 |
| Luxury   | 127.8 | 59.7      | 118.0  | 29.5 | 350.1 | 122   |
| Upper Upscale                                    | 115.6 | 54.1      | 106.7  | 28.2 | 500.9 | 482   |
| Upscale  | 92.1  | 41.0      | 85.0   | 22.0 | 543.8 | 781   |
| Upper Midscale                                   | 98.1  | 62.2      | 79.1   | 19.1 | 474.7 | 524   |
| Midscale   | 77.8  | 34.4      | 69.7   | 17.2 | 194.2 | 74    |
| Economy  | 72.6  | #DIV/0!   | 72.6   | 72.6 | 72.6  | 1     |
| 5 Stars  | 137.1 | 60.7      | 134.9  | 29.5 | 350.1 | 51    |
| 4 Stars  | 117.2 | 47.1      | 105.3  | 30.3 | 500.9 | 331   |
| 3 Stars  | 97.5  | 55.1      | 87.3   | 21.4 | 543.8 | 1,191 |
| 2 Stars  | 89.0  | 49.0      | 77.4   | 17.2 | 322.2 | 408   |
| Tropical   | 124.5 | 65.8      | 107.1  | 36.2 | 474.7 | 62    |
| Arid   | 81.9  | 46.5      | 73.5   | 19.1 | 358.5 | 156   |
| Temperate  | 98.8  | 51.0      | 88.2   | 21.4 | 543.8 | 1,576 |
| Cold (Continental)                               | 113.7 | 59.1      | 107.5  | 17.2 | 357.9 | 255   |
| Laundry Inc.                                     | 99.3  | 53.8      | 87.2   | 17.2 | 500.9 | 1,539 |
| Laundry Not Inc.                                 | 100.3 | 51.1      | 91.7   | 29.2 | 543.8 | 357   |

| Descriptive Stats on Energy Use per OCRM |       |           |        |       |         |       |
|--|-------|-----------|--------|-------|---------|-------|
|  | Mean  | Std. Dev. | Median | Min   | Max     | Count |
| All Properties                           | 77.0  | 73.7      | 56.1   | 25.1  | 1,172.6 | 2,042 |
| LEED Certified                           | 87.9  | 83.0      | 60.1   | 33.6  | 537.1   | 56    |
| Non-LEED Certified                       | 76.6  | 73.4      | 56.1   | 25.1  | 1,172.6 | 1,986 |
| Full Service                             | 111.7 | 61.4      | 96.1   | 29.4  | 537.1   | 566   |
| Limited Service                          | 62.8  | 72.8      | 48.7   | 25.1  | 1,172.6 | 1,437 |
| Luxury                                   | 154.5 | 80.2      | 135.0  | 53.0  | 401.8   | 121   |
| Upper Upscale                            | 99.6  | 48.9      | 90.2   | 29.4  | 537.1   | 458   |
| Upscale                                  | 55.3  | 20.8      | 51.0   | 26.7  | 219.4   | 805   |
| Upper Midscale                           | 75.0  | 111.4     | 45.9   | 25.1  | 1,172.6 | 567   |
| Midscale                                 | 42.4  | 28.6      | 33.3   | 25.1  | 156.5   | 67    |
| Economy                                  | 209.0 | #DIV/0!   | 209.0  | 209.0 | 209.0   | 1     |
| 5 Stars                                  | 189.9 | 67.3      | 181.7  | 56.4  | 401.8   | 50    |
| 4 Stars                                  | 107.9 | 55.2      | 93.5   | 32.8  | 537.1   | 317   |
| 3 Stars                                  | 66.5  | 70.6      | 54.5   | 25.1  | 774.8   | 1,198 |
| 2 Stars                                  | 65.3  | 89.9      | 42.2   | 25.1  | 1,172.6 | 430   |
| Tropical                                 | 74.2  | 56.1      | 54.9   | 25.8  | 358.7   | 69    |
| Arid                                     | 64.6  | 45.1      | 48.9   | 25.1  | 328.6   | 161   |
| Temperate                                | 76.6  | 71.1      | 56.9   | 25.1  | 1,172.6 | 1,540 |
| Cold (Continental)                       | 87.1  | 100.1     | 58.2   | 26.5  | 1,049.0 | 272   |
| Laundry Inc.                             | 75.4  | 78.8      | 54.0   | 25.1  | 1,172.6 | 1,537 |
| Laundry Not Inc.                         | 81.3  | 46.9      | 67.7   | 25.3  | 328.6   | 354   |

| Descriptive Stats on Energy Use per Sq. M. |       |           |        |       |         |       |
|--|-------|-----------|--------|-------|---------|-------|
|  | Mean  | Std. Dev. | Median | Min   | Max     | Count |
| All Properties                             | 300.2 | 158.5     | 260.2  | 82.0  | 1,468.7 | 2,054 |
| LEED Certified                             | 292.7 | 131.2     | 270.4  | 96.0  | 979.3   | 60    |
| Non-LEED Certified                         | 300.4 | 159.2     | 259.8  | 82.0  | 1,468.7 | 1,994 |
| Full Service                               | 366.6 | 147.1     | 342.7  | 93.9  | 1,310.3 | 598   |
| Limited Service                            | 275.0 | 156.3     | 240.0  | 82.0  | 1,468.7 | 1,374 |
| Luxury                                     | 399.3 | 159.6     | 376.7  | 96.0  | 891.3   | 123   |
| Upper Upscale                              | 355.5 | 141.7     | 334.7  | 102.9 | 1,310.3 | 485   |
| Upscale                                    | 268.4 | 99.4      | 250.1  | 82.0  | 1,093.2 | 782   |
| Upper Midscale                             | 295.7 | 216.8     | 233.0  | 84.4  | 1,468.7 | 524   |
| Midscale                                   | 202.7 | 103.8     | 189.6  | 92.9  | 840.5   | 74    |
| Economy                                    | 354.3 | #DIV/0!   | 354.3  | 354.3 | 354.3   | 1     |
| 5 Stars                                    | 428.5 | 169.2     | 422.6  | 96.0  | 891.3   | 52    |
| 4 Stars                                    | 361.1 | 129.3     | 335.8  | 102.9 | 1,310.3 | 334   |
| 3 Stars                                    | 290.6 | 157.2     | 258.6  | 82.0  | 1,417.8 | 1,191 |
| 2 Stars                                    | 257.6 | 177.6     | 217.5  | 84.4  | 1,468.7 | 408   |
| Tropical                                   | 333.4 | 187.0     | 285.2  | 105.1 | 1,232.7 | 62    |
| Arid                                       | 264.4 | 158.6     | 232.5  | 82.9  | 1,417.8 | 156   |
| Temperate                                  | 300.6 | 155.6     | 261.5  | 82.3  | 1,468.7 | 1,581 |
| Cold (Continental)                         | 311.6 | 165.6     | 275.7  | 82.0  | 1,093.8 | 255   |
| Laundry Inc.                               | 294.9 | 165.2     | 251.7  | 82.0  | 1,468.7 | 1,543 |
| Laundry Not Inc.                           | 318.9 | 137.4     | 294.1  | 91.9  | 937.8   | 357   |

| Descriptive Stats on Water Use per OCRM |         |           |         |       |         |       |
|---|---------|-----------|---------|-------|---------|-------|
|   | Mean    | Std. Dev. | Median  | Min   | Max     | Count |
| All Properties                          | 575.7   | 486.1     | 478.5   | 45.1  | 6,960.5 | 1,944 |
| LEED Certified                          | 584.5   | 487.5     | 406.4   | 201.7 | 3,062.2 | 56    |
| Non-LEED Certified                      | 575.5   | 486.2     | 479.5   | 45.1  | 6,960.5 | 1,888 |
| Full Service                            | 771.6   | 641.3     | 596.1   | 230.8 | 6,960.5 | 553   |
| Limited Service                         | 493.8   | 373.8     | 448.3   | 45.1  | 6,650.0 | 1,355 |
| Luxury                                  | 1,074.1 | 891.9     | 782.4   | 235.5 | 5,391.2 | 120   |
| Upper Upscale                           | 691.4   | 522.3     | 575.2   | 230.8 | 6,960.5 | 444   |
| Upscale                                 | 481.1   | 229.0     | 454.5   | 51.3  | 4,225.5 | 766   |
| Upper Midscale                          | 500.1   | 506.8     | 441.9   | 45.1  | 6,650.0 | 529   |
| Midscale                                | 510.4   | 401.9     | 404.4   | 147.5 | 2,712.2 | 64    |
| Economy                                 | #DIV/0! | #DIV/0!   | #NUM!   | -     | -       | -     |
| 5 Stars                                 | 1,285.7 | 443.4     | 1,002.1 | 396.1 | 4,851.0 | 47    |
| 4 Stars                                 | 758.3   | 653.1     | 586.6   | 230.8 | 6,960.5 | 311   |
| 3 Stars                                 | 519.9   | 397.5     | 473.9   | 45.1  | 6,650.0 | 1,127 |
| 2 Stars                                 | 454.5   | 537.7     | 414.6   | 46.8  | 5,220.1 | 412   |
| Tropical                                | 616.3   | 356.5     | 550.0   | 46.8  | 2,064.9 | 64    |
| Arid                                    | 612.0   | 447.2     | 541.9   | 49.7  | 4,223.5 | 157   |
| Temperate                               | 578.6   | 489.9     | 474.9   | 45.1  | 6,960.5 | 1,483 |
| Cold (Continental)                      | 523.1   | 514.1     | 451.2   | 51.3  | 6,650.0 | 240   |
| Laundry Inc.                            | 574.3   | 501.8     | 478.0   | 45.1  | 6,960.5 | 1,454 |
| Laundry Not Inc.                        | 558.6   | 398.3     | 480.3   | 49.7  | 5,391.2 | 339   |

| Descriptive Stats on Water Use per Sq. M. |         |           |         |       |          |       |
|---|---------|-----------|---------|-------|----------|-------|
|   | Mean    | Std. Dev. | Median  | Min   | Max      | Count |
| All Properties                            | 2,430.3 | 1,455.5   | 2,179.5 | 110.6 | 14,617.3 | 1,956 |
| LEED Certified                            | 2,041.4 | 1,371.9   | 1,741.3 | 486.7 | 8,001.2  | 60    |
| Non-LEED Certified                        | 2,442.6 | 1,456.7   | 2,198.1 | 110.6 | 14,617.3 | 1,896 |
| Full Service                              | 2,519.6 | 1,464.8   | 2,122.5 | 136.7 | 13,741.9 | 574   |
| Limited Service                           | 2,406.0 | 1,429.6   | 2,235.7 | 110.6 | 14,617.3 | 1,304 |
| Luxury                                    | 2,764.7 | 1,999.5   | 2,130.0 | 471.2 | 13,741.9 | 122   |
| Upper Upscale                             | 2,436.0 | 1,261.7   | 2,102.9 | 136.7 | 12,164.4 | 464   |
| Upscale                                   | 2,351.5 | 1,047.7   | 2,265.4 | 110.6 | 13,115.2 | 742   |
| Upper Midscale                            | 2,514.7 | 1,899.4   | 2,180.4 | 127.0 | 14,617.3 | 498   |
| Midscale                                  | 2,203.2 | 935.1     | 2,211.5 | 333.8 | 4,137.4  | 68    |
| Economy                                   | #DIV/0! | #DIV/0!   | #NUM!   | -     | -        | -     |
| 5 Stars                                   | 2,865.6 | 1,368.4   | 2,369.0 | 471.2 | 10,703.2 | 50    |
| 4 Stars                                   | 2,543.9 | 1,722.7   | 2,102.8 | 301.9 | 13,741.9 | 322   |
| 3 Stars                                   | 2,422.2 | 1,318.2   | 2,236.0 | 110.6 | 13,115.2 | 1,121 |
| 2 Stars                                   | 2,299.0 | 1,586.9   | 2,096.4 | 127.0 | 14,617.3 | 394   |
| Tropical                                  | 3,015.6 | 1,821.2   | 2,902.7 | 192.2 | 12,078.7 | 57    |
| Arid                                      | 2,544.5 | 1,178.5   | 2,439.5 | 219.1 | 7,025.1  | 150   |
| Temperate                                 | 2,443.4 | 1,489.7   | 2,154.5 | 122.7 | 14,617.3 | 1,509 |
| Cold (Continental)                        | 2,137.4 | 1,227.3   | 2,019.7 | 110.6 | 10,782.8 | 240   |
| Laundry Inc.                              | 2,434.1 | 1,422.1   | 2,235.7 | 110.6 | 14,617.3 | 1,470 |
| Laundry Not Inc.                          | 2,381.7 | 1,616.2   | 2,010.2 | 356.3 | 13,741.9 | 335   |

| Descriptive Stats on HCMF Footprint per OCRM |      |           |        |      |       |       |
|--|------|-----------|--------|------|-------|-------|
|  | Mean | Std. Dev. | Median | Min  | Max   | Count |
| All Properties                               | 21.9 | 13.7      | 18.1   | 5.4  | 124.2 | 1,628 |
| LEED Certified                               | 24.1 | 16.1      | 19.7   | 7.5  | 75.4  | 43    |
| Non-LEED Certified                           | 21.8 | 13.6      | 18.1   | 5.4  | 124.2 | 1,585 |
| Full Service                                 | 32.3 | 18.8      | 28.5   | 8.3  | 124.2 | 383   |
| Limited Service                              | 18.5 | 9.0       | 16.7   | 5.4  | 96.1  | 1,233 |
| Luxury                                       | 44.3 | 26.8      | 40.0   | 11.9 | 124.2 | 89    |
| Upper Upscale                                | 28.8 | 13.7      | 26.3   | 8.3  | 112.2 | 297   |
| Upscale                                      | 18.5 | 8.2       | 16.9   | 6.7  | 96.1  | 715   |
| Upper Midscale                               | 19.0 | 10.3      | 16.6   | 5.4  | 74.5  | 462   |
| Midscale                                     | 13.9 | 5.3       | 11.8   | 6.1  | 34.7  | 55    |
| Economy                                      | 47.1 | #DIV/0!   | 47.1   | 47.1 | 47.1  | 1     |
| 5 Stars                                      | 55.4 | 22.0      | 46.8   | 11.9 | 124.2 | 41    |
| 4 Stars                                      | 30.2 | 13.2      | 25.9   | 9.2  | 123.9 | 198   |
| 3 Stars                                      | 20.2 | 14.0      | 17.8   | 5.9  | 96.1  | 1,005 |
| 2 Stars                                      | 17.4 | 10.3      | 15.5   | 5.4  | 68.3  | 359   |
| Tropical                                     | 26.4 | 18.4      | 20.2   | 8.5  | 124.2 | 58    |
| Arid   | 18.9 | 11.6      | 15.7   | 6.6  | 92.3  | 150   |
| Temperate                                    | 21.1 | 12.3      | 17.9   | 5.4  | 116.9 | 1,185 |
| Cold (Continental)                           | 26.6 | 18.4      | 21.6   | 6.1  | 123.9 | 235   |
| Laundry Inc.                                 | 21.1 | 12.8      | 17.6   | 5.4  | 124.2 | 1,225 |
| Laundry Not Inc.                             | 25.1 | 16.0      | 20.4   | 5.5  | 123.9 | 335   |

| Descriptive Stats on Total Carbon Footprint / Number of Rooms |          |           |          |         |          |       |
|---|----------|-----------|----------|---------|----------|-------|
|   | Mean     | Std. Dev. | Median   | Min     | Max      | Count |
| All Properties  | 6,676.8  | 4,558.3   | 5,367.0  | 226.4   | 45,609.4 | 1,927 |
| LEED Certified  | 7,532.4  | 5,684.7   | 5,501.7  | 2,711.9 | 33,492.1 | 56    |
| Non-LEED Certified  | 6,651.2  | 4,519.7   | 5,361.1  | 226.4   | 45,609.4 | 1,871 |
| Full Service  | 9,995.5  | 5,983.2   | 8,652.1  | 2,026.0 | 45,609.4 | 569   |
| Limited Service   | 5,207.9  | 2,627.9   | 4,635.1  | 226.4   | 40,100.5 | 1,315 |
| Luxury  | 13,928.8 | 8,201.4   | 12,429.4 | 4,041.8 | 43,784.7 | 120   |
| Upper Upscale   | 8,942.5  | 4,696.1   | 8,078.7  | 2,385.1 | 45,609.4 | 461   |
| Upscale   | 5,360.4  | 2,572.1   | 4,781.0  | 226.4   | 40,100.5 | 774   |
| Upper Midscale  | 5,040.6  | 2,678.6   | 4,402.3  | 1,436.3 | 19,548.6 | 488   |
| Midscale  | 3,947.4  | 1,353.9   | 3,552.9  | 2,011.6 | 8,899.5  | 56    |
| Economy   | 7,861.5  | #DIV/0!   | 7,861.5  | 7,861.5 | 7,861.5  | 1     |
| 5 Stars   | 16,741.0 | 6,602.0   | 13,712.4 | 4,117.5 | 43,784.7 | 49    |
| 4 Stars   | 9,938.7  | 4,810.0   | 8,581.3  | 226.4   | 45,609.4 | 322   |
| 3 Stars   | 5,891.5  | 4,322.2   | 5,166.1  | 1,594.2 | 40,100.5 | 1,136 |
| 2 Stars   | 4,600.8  | 3,751.7   | 4,021.2  | 1,436.3 | 16,782.8 | 375   |
| Tropical  | 8,703.0  | 6,943.9   | 6,425.9  | 2,892.3 | 40,100.5 | 59    |
| Arid  | 5,372.3  | 3,567.2   | 4,402.2  | 1,770.2 | 30,471.0 | 151   |
| Temperate   | 6,655.6  | 4,417.1   | 5,367.5  | 226.4   | 45,609.4 | 1,474 |
| Cold (Continental)  | 7,124.3  | 4,990.1   | 5,877.1  | 1,594.2 | 43,784.7 | 243   |
| Laundry Inc.  | 6,401.0  | 4,273.4   | 5,224.8  | 1,594.2 | 45,609.4 | 1,446 |
| Laundry Not Inc.  | 7,250.2  | 4,708.0   | 5,915.1  | 226.4   | 40,100.5 | 346   |

Appendix O: Single Linear Regression Output – 2015 Water Use per SqM

| Regression Statistics |          |
|-----------------------|----------|
| Multiple R            | 0.0475   |
| R Square              | 0.0023   |
| Adjusted R Square     | 0.0017   |
| Standard Error        | 1454.234 |
| Observations          | 1956     |

| ANOVA      |      |            |         |       |                |
|------------|------|------------|---------|-------|----------------|
|            | df   | SS         | MS      | F     | Significance F |
| Regression | 1    | 9358752    | 9358752 | 4.425 | 0.036          |
| Residual   | 1954 | 4132310951 | 2114796 |       |                |
| Total      | 1955 | 4141669704 |         |       |                |

|                      | Coefficients | Standard Error | t Stat | P-value | Lower 95% | Upper 95% | Lower 95.0% | Upper 95.0% |
|----------------------|--------------|----------------|--------|---------|-----------|-----------|-------------|-------------|
| Intercept            | 2442.580     | 33.398         | 73.136 | 0.000   | 2377.082  | 2508.079  | 2377.082    | 2508.079    |
| LEED Certified (YES) | -401.142     | 190.688        | -2.104 | 0.036   | -775.116  | -27.169   | -775.116    | -27.169     |

Appendix P: Multiple Linear Regression Output – 2015 Water Use per SqM

| <i>Regression Statistics</i> |          |
|------------------------------|----------|
| Multiple R                   | 0.243    |
| R Square                     | 0.059    |
| Adjusted R Square            | 0.056    |
| Standard Error               | 1414.263 |
| Observations                 | 1956     |

| <i>ANOVA</i> |           |            |           |          |                       |
|--------------|-----------|------------|-----------|----------|-----------------------|
|              | <i>df</i> | <i>SS</i>  | <i>MS</i> | <i>F</i> | <i>Significance F</i> |
| Regression   | 7         | 245399527  | 35057075  | 17.527   | 1.160E-22             |
| Residual     | 1948      | 3896270177 | 2000139   |          |                       |
| Total        | 1955      | 4141669704 |           |          |                       |

|                     | <i>Coefficients</i> | <i>Standard Error</i> | <i>t Stat</i> | <i>P-value</i> | <i>Lower 95%</i> | <i>Upper 95%</i> | <i>Lower 95.0%</i> | <i>Upper 95.0%</i> |
|---------------------|---------------------|-----------------------|---------------|----------------|------------------|------------------|--------------------|--------------------|
| Intercept           | 125573.747          | 50072.199             | 2.508         | 0.012          | 27373.025        | 223774.469       | 27373.025          | 223774.469         |
| Yes                 | -449.384            | 185.678               | -2.420        | 0.016          | -813.533         | -85.235          | -813.533           | -85.235            |
| >267                | 213.038             | 77.874                | 2.736         | 0.006          | 60.312           | 365.764          | 60.312             | 365.764            |
| 150-267             | 198.199             | 79.915                | 2.480         | 0.013          | 41.471           | 354.927          | 41.471             | 354.927            |
| HDD 2015            | -5.341              | 2.116                 | -2.524        | 0.012          | -9.491           | -1.191           | -9.491             | -1.191             |
| CDD 2015            | 5.492               | 2.163                 | 2.539         | 0.011          | 1.249            | 9.734            | 1.249              | 9.734              |
| Average Annual Temp | -1899.320           | 770.822               | -2.464        | 0.014          | -3411.043        | -387.598         | -3411.043          | -387.598           |
| Relative Humidity   | 6.666               | 2.616                 | 2.548         | 0.011          | 1.536            | 11.796           | 1.536              | 11.796             |

## Appendix Q: 2014 LEED vs. Non-LEED Means Comparison for CHSB Metrics

| 2014   |        |                    |            |
|--|--------|--------------------|------------|
| Metric   | Value  | Unit               | Difference |
| <b>Average of HCMI Footprint per Occupied Room</b>           |        |                    |            |
| Not LEED Certified   | 22.2   | HCMI metric        | 12.7%      |
| LEED Certified   | 25.0   |                    |            |
| <b>Average of Total Carbon Footprint / # of Rooms</b>        |        |                    |            |
| Not LEED Certified   | 6825.8 | kgCO <sub>2e</sub> | 16.5%      |
| LEED Certified   | 7948.7 |                    |            |
| <b>Average of Total Carbon Footprint per OCRM</b>            |        |                    |            |
| Not LEED Certified   | 25.1   | kgCO <sub>2e</sub> | 20.4%      |
| LEED Certified   | 30.3   |                    |            |
| <b>Average of Total Carbon Footprint per Floor Area sq.M</b> |        |                    |            |
| Not LEED Certified   | 102.8  | kgCO <sub>2e</sub> | -4.1%      |
| LEED Certified   | 98.6   |                    |            |
| <b>Average of Total Energy Use per OCRM</b>                  |        |                    |            |
| Not LEED Certified   | 74.9   | kWh                | 22.1%      |
| LEED Certified   | 91.4   |                    |            |
| <b>Average of Total Energy Use per Floor Area sq.m</b>       |        |                    |            |
| Not LEED Certified   | 303.4  | kWh                | -2.2%      |
| LEED Certified   | 296.8  |                    |            |
| <b>Average of Total Water Use per OCRM</b>                   |        |                    |            |
| Not LEED Certified   | 604.1  | L                  | -6.6%      |
| LEED Certified   | 564.3  |                    |            |
| <b>Average of Total Water Use per Floor Area sq.m</b>        |        |                    |            |
| Not LEED Certified   | 2491.8 | L                  | -17.4%     |
| LEED Certified   | 2059.2 |                    |            |

## Appendix R: Data Cuts for Sustainability Metrics on a Per Square Meter Basis

| Data Cuts - Sustainability Metrics per SqM by Service Classification |        |                       |
|--|--------|-----------------------|
| Variable   | Value  | % Difference for LEED |
| <b>Average of Total Carbon Footprint per Floor Area sq.M</b>         |        |                       |
| <b>Full Service</b>  |        |                       |
| No   | 118.9  |                       |
| Yes  | 113.5  | -4.6%                 |
| <b>Limited Service</b>   |        |                       |
| No   | 93.6   |                       |
| Yes  | 85.4   | -8.8%                 |
| <b>Average of Total Energy Use per Floor Area sq.m</b>               |        |                       |
| <b>Full Service</b>  |        |                       |
| No   | 367.5  |                       |
| Yes  | 345.1  | -6.1%                 |
| <b>Limited Service</b>   |        |                       |
| No   | 275.5  |                       |
| Yes  | 254.1  | -7.8%                 |
| <b>Average of Total Water Use per Floor Area sq.m</b>                |        |                       |
| <b>Full Service</b>  |        |                       |
| No   | 2523.6 |                       |
| Yes  | 2427.4 | -3.8%                 |
| <b>Limited Service</b>   |        |                       |
| No   | 2421.1 |                       |
| Yes  | 1806.9 | -25.4%                |

## Data Cuts - Sustainability Metrics per SqM by Climate Zone

| Variable   | Value  | % Difference for LEED |
|--|--------|-----------------------|
| <b>Average of Total Carbon Footprint per Floor Area sq.M</b> |        |                       |
| <b>Arid</b>  |        |                       |
| No   | 82.6   |                       |
| Yes  | 64.3   | -22.2%                |
| <b>Cold (Continental)</b>                                    |        |                       |
| No   | 113.9  |                       |
| Yes  | 108.4  | -4.8%                 |
| <b>Temperate</b>   |        |                       |
| No   | 98.8   |                       |
| Yes  | 99.4   | 0.6%                  |
| <b>Tropical</b>  |        |                       |
| No   | 123.8  |                       |
| Yes  | 163.9  | 32.4%                 |
| <b>Average of Total Energy Use per Floor Area sq.m</b>       |        |                       |
| <b>Arid</b>  |        |                       |
| No   | 266.4  |                       |
| Yes  | 213.7  | -19.8%                |
| <b>Cold (Continental)</b>                                    |        |                       |
| No   | 310.9  |                       |
| Yes  | 338.1  | 8.7%                  |
| <b>Temperate</b>   |        |                       |
| No   | 300.7  |                       |
| Yes  | 295.1  | -1.9%                 |
| <b>Tropical</b>  |        |                       |
| No   | 332.6  |                       |
| Yes  | 382.2  | 14.9%                 |
| <b>Average of Total Water Use per Floor Area sq.m</b>        |        |                       |
| <b>Arid</b>  |        |                       |
| No   | 2559.1 |                       |
| Yes  | 2286.0 | -10.7%                |
| <b>Cold (Continental)</b>                                    |        |                       |
| No   | 2145.2 |                       |
| Yes  | 1767.5 | -17.6%                |
| <b>Temperate</b>   |        |                       |
| No   | 2456.3 |                       |
| Yes  | 2034.5 | -17.2%                |
| <b>Tropical</b>  |        |                       |
| No   | 3037.8 |                       |
| Yes  | 1773.4 | -41.6%                |

## Data Cuts - Sustainability Metrics per SqM by Chain Scale

| Variable   | Value  | % Difference for LEED |
|--|--------|-----------------------|
| <b>Average of Total Carbon Footprint per Floor Area sq.M</b> |        |                       |
| <b>Luxury</b>  |        |                       |
| No   | 130.2  |                       |
| Yes  | 93.8   | -28.0%                |
| <b>Upper Midscale</b>  |        |                       |
| No   | 98.4   |                       |
| Yes  | 74.2   | -24.6%                |
| <b>Upper Upscale</b>   |        |                       |
| No   | 115.3  |                       |
| Yes  | 124.8  | 8.2%                  |
| <b>Upscale</b>   |        |                       |
| No   | 92.3   |                       |
| Yes  | 87.2   | -5.5%                 |
| <b>Average of Total Energy Use per Floor Area sq.m</b>       |        |                       |
| <b>Luxury</b>  |        |                       |
| No   | 404.2  |                       |
| Yes  | 328.6  | -18.7%                |
| <b>Upper Midscale</b>  |        |                       |
| No   | 296.5  |                       |
| Yes  | 228.9  | -22.8%                |
| <b>Upper Upscale</b>   |        |                       |
| No   | 355.6  |                       |
| Yes  | 353.3  | -0.6%                 |
| <b>Upscale</b>   |        |                       |
| No   | 268.9  |                       |
| Yes  | 256.8  | -4.5%                 |
| <b>Average of Total Water Use per Floor Area sq.m</b>        |        |                       |
| <b>Luxury</b>  |        |                       |
| No   | 2802.3 |                       |
| Yes  | 2292.6 | -18.2%                |
| <b>Upper Midscale</b>  |        |                       |
| No   | 2524.0 |                       |
| Yes  | 1751.4 | -30.6%                |
| <b>Upper Upscale</b>   |        |                       |
| No   | 2433.6 |                       |
| Yes  | 2508.2 | 3.1%                  |
| <b>Upscale</b>   |        |                       |
| No   | 2374.2 |                       |
| Yes  | 1791.2 | -24.6%                |

## Data Cuts - Sustainability Metrics per SqM by Building Size per SqM

| Variable   | Value  | % Difference for LEED |
|--|--------|-----------------------|
| <b>Average of Total Carbon Footprint per Floor Area sq.M</b> |        |                       |
| <b>Small</b>   |        |                       |
| No   | 102.0  |                       |
| Yes  | 144.5  | 41.7%                 |
| <b>Medium</b>  |        |                       |
| No   | 91.3   |                       |
| Yes  | 91.4   | 0.2%                  |
| <b>Large</b>   |        |                       |
| No   | 103.2  |                       |
| Yes  | 82.2   | -20.3%                |
| <b>Extra-Large</b>   |        |                       |
| No   | 104.7  |                       |
| Yes  | 96.5   | -7.9%                 |
| <b>Average of Total Energy Use per Floor Area sq.m</b>       |        |                       |
| <b>Small</b>   |        |                       |
| No   | 299.2  |                       |
| Yes  | 447.3  | 49.5%                 |
| <b>Medium</b>  |        |                       |
| No   | 264.6  |                       |
| Yes  | 248.3  | -6.2%                 |
| <b>Large</b>   |        |                       |
| No   | 307.2  |                       |
| Yes  | 257.1  | -16.3%                |
| <b>Extra-Large</b>   |        |                       |
| No   | 331.1  |                       |
| Yes  | 290.1  | -12.4%                |
| <b>Average of Total Water Use per Floor Area sq.m</b>        |        |                       |
| <b>Small</b>   |        |                       |
| No   | 2520.5 |                       |
| Yes  | 2147.3 | -14.8%                |
| <b>Medium</b>  |        |                       |
| No   | 2340.2 |                       |
| Yes  | 1829.0 | -21.8%                |
| <b>Large</b>   |        |                       |
| No   | 2273.8 |                       |
| Yes  | 1829.1 | -19.6%                |
| <b>Extra-Large</b>   |        |                       |
| No   | 2575.6 |                       |
| Yes  | 2292.5 | -11.0%                |

# Appendix V: Data Cut for In-House Laundry by Service Type (with additional filters)

