

CHAPTER 5

DISCUSSION, CONCLUSIONS & RECOMMENDATIONS

5.1: INTRODUCTION

Green building offers a method in which buildings can reduce energy consumption and emission outputs; however, not all green buildings will perform at the same capacity, as LEED buildings are certified based in part, on a series of estimates, i.e., modeled energy and water use, actual performance data must be used to determine built performance. In this chapter, variation of post-occupancy performance and the variables which affect performance are discussed. Performance data of ISB's Gold certified Cultural Center is summarized and concluded. Areas of weakness are identified, and recommendations for the improvement of LEED certification in Thailand are given. Chapter 5 presents a critical analysis using current research findings and aggregate findings from previous studies to discuss, conclude, and present recommendations relevant to stakeholders. Primary stakeholders are identified as follows: Thai government, LEED industry, certified design professionals, and LEED investors.

5.2: DISCUSSION & CONCLUSIONS: EKC

Study results show that Thailand does exhibit an Environmental Kuznets Curve. As GDP increased to the critical level (5,000 to 6,000 USD), air quality metrics such as CO, NO₂, PM₁₀ and SO₂, consistently fell (Grossman & Krueger, 2009). This supports the research theory that once the critical level of wealth is achieved, governments begin the process of environmental clean-up, resulting in increased environmental regulations and enforcement. The recent decision to halt the new Ford Motor Company expansion is evidence that environmental protests and concerns are beginning to take some precedence over economic and business considerations. This suggests that naturally as Thailand continues towards first world status, environmental

regulations and enforcement will continue to increase, thus increasing the financial burden associated with environmental regulations. As regulatory costs increase, the trend in green building is predicted to increase, as sustainable building practices allow businesses to reduce compliance cost while simultaneously lowering emissions. Further, evidence shows that the green building trend is increasing in Thailand. At the start of this study, there were 5 LEED certified buildings and 8 registered buildings. In just a few years' time, these figures increased dramatically; today there are 13 certified buildings and 43 registered projects (U.S. Green, project registry, 2011). This represents a 160 percent increase in the number of LEED certified buildings and a 600 percent increase in the number of registered projects.

Currently, there is a lack of industry research analyzing post-occupancy performance. Performance studies that are applicable to Thailand are nonexistent; this study is the first regional example. The previous studies are demographically isolated and do not address regional benefits. Analyzing regional, post-occupancy performance of Thai LEED certified buildings provides valuable insight from which stakeholders can estimate and benchmark performance, improve performance by identifying trends of strength and weakness, and improve the accuracy of cost benefit analyses to better evaluate future investments.

5.2.1: POST-OCCUPANCY PERFORMANCE

The post-occupancy performance analysis of ISB's Cultural Center reveals that ISB exceeded its performance target resulting in a direct financial and environmental benefit. Energy performance was 14 percent greater than predicted, representing a 40 percent energy reduction over the baseline model. ISB exhibits a performance benefit over non-LEED buildings, indicated by a measured EUI, which is 63 percent lower than the national average and 37 percent lower than the sector-based average. The largest post-occupancy performance study conducted by New Building Institute estimated energy savings between 25 and 30 percent, which is much higher than the subsequent study (Turner & Frankel, 2008). The "Regional Green Building Case Study Project" estimated energy savings at 5 percent (USGBC, 2009). Both of the

previous studies found a large range in performance variability when comparing measured performance to modeled performance and in measured EUI. The analysis of ISB's Cultural Center is presented as a case study; therefore, performance variability cannot be expressed; however, it must be noted that in multiple sample scenarios, performance variability should be expected.

When examining LEED performance, it is important to remember that LEED accreditation is not a one design fits all process, and there are many different design features used to optimize performance. While some designs may meet or exceed their predicted performance, others may fall drastically short, as identified in the previous studies. Furthermore, energy efficiency will fluctuate over the life span of a building due to a multitude of variables, such as temperature, energy cost fluctuation, life span and maintenance of mechanical features, specifications of replacements and deterioration of building components, etc. As a building's mechanical equipment ages, it becomes less energy efficient, and therefore affects overall building performance. Additionally, some of the mechanical equipment will need replacement during the life of the building, and the specifications of replacement can greatly impact performance. As it is often impossible to find replacements with the exact specifications, substitutions are often made (Fallowfield, Katie, personal communication, May 15, 2012). If a replacement is less energy efficient, overall energy performance will be lowered; however, if the replacement is more energy efficient, performance may be increased. It is to be expected that by the time replacements are needed, new technology will make replacements more efficient; however, less efficient models may still be specified. Numerous variables can significantly affect overall performance, showing that variability of building deterioration and maintenance play a critical role.

The combined results of post-occupancy performance studies have indicated there is an overall performance benefit when comparing LEED to non-LEED performance. It must be noted that ISB exhibited a measured EUI that was much higher than the previous studies estimated. As it has been discussed, there are many variables that affect individual building performance. ISB's increased performance suggests there

is an additional, regional benefit. As climate and temperature can significantly affect performance, regions which exhibit less seasonal fluctuation may experience a greater performance benefit. In regions where buildings must be designed for both hot and cold weather, energy efficient designs present greater difficulty. For example, in tropical regions such as Thailand, design features do not have to address both extreme winter and summer conditions. Designing proper overhangs and building orientation can effectively shade and cool a building, reducing the energy consumed through air conditioning. In regions where seasonal extremes are a factor, overhangs designed to reduce the energy needed to cool a building in the summer months, may result in higher energy consumption used to heat the building during winter months. Additionally, on-site energy generation, such as photovoltaic energy, will be more productive in regions that exhibit consistently, sunnier weather patterns. Clearly, ISB's increased EUI measurement indicates the probable existence of an additional, regional benefit.

In conclusion, ISB exhibits both significant financial and environmental benefits. Measured performance has exceeded the predicted performance, signifying that in this case, the measured value is higher than expected investment value. After combining all post-occupancy performance research results, it is determined that there is an overall performance benefit of LEED to non-LEED buildings; however, individual building performance is widely variable.

5.2.2: ADDITIONAL PERCEIVED BENEFITS

Similar to the findings of previous performance studies, ISB's surveyed results reveal that occupant comfort and satisfaction is quite high. Research studies designed to quantify the value of perceived benefits have demonstrated significant financial gains. Expected benefits include customer retention and attraction, decreased operation and maintenance cost, greater productivity, employee retention and recruitment, and increased tenancy and rental values. Research shows that LEED certification increases customer retention and attraction by an estimated 73 percent (Bernstein, 2011). Additionally, studies have indicated that LEED certification exhibits an

increase in tenant demand. Forty-nine percent of tenants surveyed indicated a willingness to pay green premiums. Twenty-nine percent expressed that they were willing to accept increases between 1 and 10 percent, while 8 percent said they were willing to pay 10 percent or more (Bernstein, 2011). Moreover, 61 percent of corporate leaders agreed that, "Sustainability leads to market differentiation and helps improve financial performance" (Bernstein, 2011). Additional perception benefits associated with increased demand and differentiation premiums are applicable to ISB. These benefits could potentially result in higher future enrollment and increased tuition prices. In this case study, evidence supports the existence of additional financial benefits resulting from ISB's LEED investment. Additional benefits could significantly increase the overall performance value of ISB's Cultural Center.

5.2.3: HYPOTHESIS CONCLUSION

Research Question 1: Are LEED certified buildings performing as predicted, resulting in financial and environmental benefits?

H1: Sustainable buildings, although a higher initial cost, will provide long term financial and environmental benefits.

Conclusion 1: ISB's measured performance exceeds predicted performance estimates resulting in both financial and environmental performance benefits over non-LEED certified buildings. Aggregate post-occupancy performance data reveals an overall performance benefit of LEED to non-LEED buildings; however, individual building performance results are highly variable.

Research Question 2: Are there any additional benefits of LEED certification that result in increased performance benefits?

H2: Perceived performance benefits associated with LEED certification such as increased comfort, satisfaction, health and, productivity result in increased performance benefits.

Conclusion 2: ISB's additional perceived performance analysis shows comfort and satisfaction rankings to be quite high, indicating that there are additional performance benefits associated with LEED certification. Similarly, aggregate post-occupancy results indicate the existence of additional perceived performance benefits. Additionally, benefits have been shown to provide significant financial savings.

5.3: RECOMMENDATIONS: POST-OCCUPANCY PERFORMANCE

Research has concluded that there are significant performance benefits derived from LEED certification. Green building certification has increased worldwide and this trend, mirrored by the rapid growth of LEED certification in Thailand, is clearly shown. Market research shows that the green share of new construction in America has increased from 12 percent in 2008 to 35 percent in 2010 and is estimated to hold a 48 percent market share by 2015 (Bernstein, 2011). To estimate the environmental benefit, the highest, most commonly accepted green premium (3 percent), and an average energy savings of 25 to 30 percent is assumed. Using these figures, it is estimated that green buildings will reduce new-building energy consumption (in 2015) between 11.25 and 13.5 percent. Building construction and operation account for a significant amount of energy consumption and GHG emissions worldwide. The increased interest in green building presents an opportunity for the Thai government to minimize environmental risks, while shifting some of the burden to the non-government sector. Furthermore, Thailand's CO₂ emissions from fuel combustion have increased by 202.4 percent between 1990 and 2008 (Tanala, 2010). Thailand has the fourth highest CO₂ emissions out of the eighteen referenced Asian countries, excluding China. The current worldwide emphasis to reduce energy consumption has resulted in international collaborations designed to address environmental concerns, and carbon credit permit systems have long been underway. The adoption of international environmental agreements could have a significant impact on the future of multilateral trade. It is pertinent for governments to encourage efforts and adopt standards that are designed to reduce energy consumption and emissions. Significantly reducing national emission levels and energy consumption provides substantial economic gains and risk avoidance. Environmental concerns pose severe

risks to Thailand, as presented in Chapter 1; economic value and risks are discussed in great detail. Many countries already offer tax incentives designed to encourage green investment, and tax incentives are shown to increase the expected benefit of LEED by 39 percent (Bernstein, 2011). It is recommended that Thailand's government adopt an incentive program to promote green building, as there are significant environmental and economic benefits.

As previous research has indicated a wide variability in individual performance, it is recommended that further research be conducted to establish the areas which exhibit maximum and minimum performance benefits. Additionally, this case study provides evidence of an additional regional benefit. To date, there is very little post-occupancy research, and with extremely limited data, additional studies are recommended. Once there have been a sufficient number of research studies conducted, results can be aggregated and a definitive performance range can be established. Sufficient research will allow the LEED industry and design professionals to identify trends of weakness and improve the certification process in order to increase performance benefits, both in terms of overall aggregate performance and regional performance. Additionally, once a definitive performance range has been accepted, investors will be able to make accurate cost benefit analyses and better estimate expected value of future investments.

5.3.1: ADDITIONAL PERCEIVED BENEFITS

Evidence indicates the existence of perceived performance benefits, which have been shown to increase productivity, health, and occupant comfort and satisfaction. This research should be expanded upon to include a regional, post-occupancy performance analysis of the financial gains in terms of net present value. The additional perceived benefit analysis highlights areas which may be used to improve occupant comfort and satisfaction. For example, the occupant comfort and satisfaction survey of ISB's Cultural Center revealed reoccurring, occupant dissatisfaction with the eco-friendly light sensors. In this instance, design professionals are able to identify an area of improvement. Improvement of eco-friendly light sensors could result in increased

specifications of such features. It has been recognized that occupants' dissatisfaction often decreases design performance. For instance, occupants may choose to shut off eco-friendly light settings in favor of manual operation, in turn, reducing design performance. By identifying and remedying this problem, design performance can be increased. Lastly, as this research is limited by the small population, further research is recommended. As the population of Thai LEED certified buildings grow, longer and more abundant data sets will provide stakeholders with a definitive picture of overall performance.

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