

**Sustainable Retrofits in Existing Buildings**

**Analysis of Stakeholder Types, Requirements, and Perceptions in Decision  
Making, using the House of Quality**

by

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This thesis is dedicated to my wife and our three children.

“UNLESS someone like you cares a whole awful lot, nothing is going to get better.

It’s not. (Seuss 1971).”

The views expressed in this thesis are those of the author and do not reflect the official policy or position of the United States Navy, Department of Defense, or the United States Government.

**Abstract:**

There are multiple reasons why existing building stakeholders are concerned with increasing the sustainability of their buildings from social, environmental, economic, and technical perspectives. In most cases, these building stakeholders have varying and opposing perspectives on how, when, and why a building should be sustainably retrofitted. Several studies indicate that conflicting stakeholder requirements are a main barrier in implementing sustainable retrofits and that the decision is most often made based purely on short-term economic grounds. However, most studies did not take into account the important role that different building stakeholders play in determining the type and extent of any retrofit measures, or develop methodologies to fully enhance the interaction amongst these stakeholders which currently do not exist. This research presents a unique investigation into the challenges and barriers that are involved in meeting the various sustainable retrofit requirements of many different types of stakeholders. In this research, the effect of the stakeholder type and the hierarchy of their respective requirements in the decision to sustainably retrofit an existing U.S. Navy case study building were explored. A House of Quality (HOQ) model was developed through this research that synthesized differences amongst the many stakeholders, integrated their competing objectives, and a new way of analyzing HOQ data was introduced. This research demonstrated that a top-down owner commitment to sustainability was able to align the many competing stakeholder requirements and eliminate barriers that could potentially get in the way of efficient project decisions and results. The retrofit decision in this case study was based primarily on delivering economic impacts. However, the harmony between perceptions concerning social, environmental, and economic factors was not substantially out of balance and on the forefront of the policy that aligned the stakeholders.

## Table of Contents

|   |            |
|---|------------|
| <b>ABSTRACT:</b> .....  | <b>I</b>   |
| <b>TABLE OF CONTENTS</b> .....  | <b>II</b>  |
| <b>LIST OF FIGURES</b> .....  | <b>V</b>   |
| <b>LIST OF TABLES</b> .....   | <b>VII</b> |
| <b>CHAPTER 1: INTRODUCTION</b> .....  | <b>1</b>   |
| <b>CHAPTER 2: LITERATURE REVIEW</b> .....   | <b>6</b>   |
| 2.1 – <i>MOTIVATIONS FOR THE PURSUIT OF SUSTAINABLE RETROFITS</i> .....   | 6          |
| 2.2 – <i>BARRIERS TO THE IMPLEMENTATION OF SUSTAINABLE RETROFITS</i> .....  | 8          |
| 2.3 – <i>CONFLICTING STAKEHOLDER REQUIREMENTS</i> .....   | 11         |
| 2.4 – <i>IMPLICATION OF SUSTAINABLE DEVELOPMENT AND DECISION MAKING</i> .....                                       | 14         |
| 2.4.1 – <i>Uncertainties in Energy Pricing and Climate Change</i> .....   | 14         |
| 2.4.2 – <i>Decision Making Methodologies</i> .....  | 15         |
| 2.4.3 – <i>Long Term Social and Environmental Benefits</i> .....  | 17         |
| 2.5 – <i>SUMMARY OF LITERATURE REVIEW</i> .....   | 18         |
| <b>CHAPTER 3: RESEARCH OBJECTIVES</b> .....   | <b>22</b>  |
| 3.1 – <i>OBJECTIVES</i> .....   | 22         |
| <b>CHAPTER 4: METHODOLOGY</b> .....   | <b>24</b>  |
| 4.1 – <i>INTRODUCTION TO THE HOUSE OF QUALITY</i> .....   | 24         |
| 4.2 – <i>RESEARCH PROCESS</i> .....   | 26         |
| 4.3 – <i>LITERATURE REVIEW, THE HOUSE OF QUALITY</i> .....  | 27         |
| 4.3.1 – <i>Quality Function Deployment and the House of Quality</i> .....   | 27         |
| 4.3.2 – <i>House of Quality Application in the Architecture, Engineering, and Construction (AEC) Industry</i> ..... | 28         |
| 4.3.3 – <i>House of Quality Limitations in AEC Industry Applications</i> .....                                      | 31         |
| 4.3.4 – <i>House of Quality Advancements in AEC Industry Applications</i> .....                                     | 33         |
| 4.3.5 – <i>House of Quality: Energy Performance and Sustainability</i> .....  | 37         |
| 4.4 – <i>DEVELOPMENT OF THE HOUSE OF QUALITY FOR SUSTAINABLE RETROFITS IN EXISTING BUILDINGS</i> .....              | 38         |
| 4.4.1 – <i>Step 1: Stakeholder Requirements</i> .....   | 39         |
| 4.4.2 – <i>Step 2: Technical Characteristics Matrix</i> .....   | 43         |
| 4.4.3 – <i>Step 3: Relationship Matrix</i> .....  | 44         |
| 4.4.4 – <i>Step 4: Technical Targets Matrix</i> .....   | 47         |
| 4.4.5 – <i>Planning Matrix</i> .....  | 51         |
| 4.4.6 – <i>Technical Correlation Matrix (“Roof”)</i> .....  | 52         |
| 4.5 – <i>HOUSE OF QUALITY SURVEY DEVELOPMENT</i> .....  | 53         |
| 4.5.1 – <i>Importance and Relationship Matrix Questionnaire</i> .....   | 53         |
| 4.5.2 – <i>Building Occupant Satisfaction Survey</i> .....  | 56         |
| 4.6 – <i>DATA ANALYSIS PROCEDURES</i> .....   | 58         |
| 4.6.1 – <i>Average used for Final HOQ Results</i> .....   | 58         |
| 4.6.2 – <i>Comparing the HOQ Results from Different Stakeholder Groups</i> .....                                    | 60         |

|  |            |
|--|------------|
| 4.6.3 – <i>Analysis of Interval Data</i> .....   | 61         |
| 4.7 – <i>SUMMARY OF METHODOLOGY</i> .....  | 63         |
| <b>CHAPTER 5:    CASE STUDY</b> .....  | <b>64</b>  |
| 5.1 – BUILDING DESCRIPTION .....   | 64         |
| 5.2 – STAKEHOLDERS .....   | 67         |
| 5.3 – DATA COLLECTION .....  | 68         |
| 5.3.1 – <i>House of Quality Importance and Relationship Matrix Questionnaire</i> .....   | 68         |
| 5.3.2 – <i>Building Occupant Satisfaction Survey</i> .....   | 71         |
| <b>CHAPTER 6: RESULTS</b> .....  | <b>73</b>  |
| 6.1 – CASE STUDY, FINAL HOQ RESULTS: .....   | 75         |
| 6.2 – TECHNICAL TARGETS MATRIX: STAKEHOLDER COMPARISON.....  | 82         |
| 6.3 –IMPORTANCE AND TECHNICAL IMPORTANCE RATINGS FOR COMPETING STAKEHOLDER REQUIREMENTS 88   |            |
| 6.3.1 – <i>Importance Rating</i> .....   | 89         |
| 6.3.2 – <i>Technical Importance of Mechanical System Retrofits</i> .....   | 94         |
| 6.3.3 – <i>Technical Importance of Electrical System Retrofits</i> .....   | 95         |
| 6.3.4 – <i>Technical Importance of Plumbing System Retrofits</i> .....   | 97         |
| 6.3.5 – <i>Technical Importance of Building Envelope Retrofits</i> .....   | 99         |
| 6.3.6 – <i>Summary of Overall Importance and Technical Importance Ratings for the Competing Stakeholder Requirements</i> .....             | 102        |
| 6.4 – EFFECT OF STAKEHOLDER TYPE ON THE RETROFIT DECISION .....  | 108        |
| 6.4.1 – <i>Facility Managers versus Designers, Electrical System Retrofits</i> .....   | 109        |
| 6.4.2 – <i>Opposing Stakeholder Groups</i> .....   | 114        |
| 6.4.2.1 – <i>Facility Managers versus Designers, Importance Rating</i> .....   | 116        |
| 6.4.2.2 – <i>Tenants versus Owners, Importance Rating</i> .....  | 119        |
| 6.5 – SOCIAL, ENVIRONMENTAL, AND ECONOMIC SUSTAINABILITY CONSIDERATIONS .....  | 123        |
| 6.5.1 – <i>House of Quality for Social, Environmental, and Economic Considerations</i> .....   | 125        |
| 6.5.2 – <i>Main Stakeholder Requirements for Each Sustainability Consideration</i> .....   | 130        |
| 6.5.3 – <i>Summary: Social, Environmental, and Economic Sustainability Considerations</i> .....  | 134        |
| 6.6 – LIMITATIONS OF THE RESULTS AND DATA.....   | 135        |
| <b>CHAPTER 7:    CONCLUSIONS AND RECOMMENDATIONS</b> .....   | <b>139</b> |
| 7.1 – <i>Conclusions</i> .....   | 139        |
| 7.2 – <i>Recommendations</i> .....   | 143        |
| <b>REFERENCES</b> .....  | <b>143</b> |
| <b>APPENDIX A – HOQ IMPORTANCE AND RELATIONSHIP SURVEY QUESTIONNAIRE</b> ...A-1  |            |
| <b>APPENDIX B – HOQ IMPORTANCE DATA AND CALCULATIONS</b> .....   | <b>B-1</b> |
| <b>APPENDIX C – HOQ MECHANICAL SYSTEM RETROFIT RELATIONSHIP DATA, TECHNICAL IMPORTANCE CALCULATIONS, AND DATA ANALYSIS CALCULATIONS...</b> |            |
| .....  | <b>C-1</b> |

|   |            |
|---|------------|
| <b>APPENDIX D – HOQ ELECTRICAL SYSTEM RETROFIT RELATIONSHIP DATA,<br/>TECHNICAL IMPORTANCE CALCULATIONS, AND DATA ANALYSIS CALCULATIONS</b><br>.....                  | <b>D-1</b> |
| <b>APPENDIX E – HOQ PLUMBING SYSTEM RETROFIT RELATIONSHIP DATA,<br/>TECHNICAL IMPORTANCE CALCULATIONS, AND DATA ANALYSIS CALCULATIONS</b><br>.....                    | <b>E-1</b> |
| <b>APPENDIX F – HOQ BUILDING ENVELOPE RETROFIT RELATIONSHIP DATA,<br/>TECHNICAL IMPORTANCE CALCULATIONS, AND DATA ANALYSIS CALCULATIONS...</b><br>.....               | <b>F-1</b> |
| <b>APPENDIX G – HOQ SOCIAL SUSTAINABILITY CONSIDERATIONS RELATIONSHIP<br/>DATA, TECHNICAL IMPORTANCE CALCULATIONS, AND DATA ANALYSIS<br/>CALCULATIONS.....</b>        | <b>G-1</b> |
| <b>APPENDIX H – HOQ ENVIRONMENTAL SUSTAINABILITY CONSIDERATIONS<br/>RELATIONSHIP DATA, TECHNICAL IMPORTANCE CALCULATIONS, AND DATA<br/>ANALYSIS CALCULATIONS.....</b> | <b>H-1</b> |
| <b>APPENDIX I – HOQ ECONOMIC SUSTAINABILITY CONSIDERATIONS RELATIONSHIP<br/>DATA, TECHNICAL IMPORTANCE CALCULATIONS, AND DATA ANALYSIS<br/>CALCULATIONS.....</b>      | <b>I-1</b> |
| <b>APPENDIX J – INDIVIDUAL HOQ’S FOR EACH STAKEHOLDER GROUP .....</b>   | <b>J-1</b> |
| <b>APPENDIX K – OCCUPANT SATISFACTION SURVEY .....</b>  | <b>K-1</b> |
| <b>APPENDIX L – DATA AND CALCULATIONS: OCCUPANT SATISFACTION SURVEY .....</b>   | <b>L-1</b> |
| <b>ACKNOWLEDGEMENTS.....</b>  | <b>I</b>   |

## List of Figures

|  |     |
|--|-----|
| Figure 1 – Research Process.....   | 26  |
| Figure 2 – The House of Quality (adapted from Delgado-Hernandez et al. 2007) .....   | 28  |
| Figure 3 – House of Quality for Buildability (HOQBD, Yang et al. 2003).....  | 35  |
| Figure 4 – House of quality (HOQ) Roof (Ahmed et al 2003).....   | 36  |
| Figure 5 - Basic House of Quality Template, Labeled Per this Research Application .....                                    | 39  |
| Figure 6 – Stakeholder Requirements Matrix.....  | 41  |
| Figure 7 – Technical Characteristics Matrix .....  | 44  |
| Figure 8 – Stakeholder Requirements, Technical Characteristics, and Relationship Matrices.....                             | 46  |
| Figure 9 – Example Calculation: Individual Technical Importance (EQ. 1) .....  | 47  |
| Figure 10 – HOQ for Sustainable Retrofits in Existing Buildings .....  | 49  |
| Figure 11 – Example Calculations: Technical Importance (EQ. 2) and Relative Weight (EQ. 3) .....                           | 50  |
| Figure 12 - Example Occupant Satisfaction Technical Targets Matrix Comparison.....   | 58  |
| Figure 13 – Case Study Barracks Building, Naval Station Great Lakes, IL .....  | 65  |
| Figure 14 – HOQ for Technical Considerations, Equal Stakeholder Group Representation .....                                 | 77  |
| Figure 15 – Technical Targets Matrix, Sustainable Retrofit Measures .....  | 78  |
| Figure 16 – Sample Calculation, Percent Technical Importance.....  | 78  |
| Figure 17 – Technical Targets Matrix: Comparison by Stakeholder .....  | 83  |
| Figure 18 – Comparison of Relative Weight by Stakeholder Group and Retrofit Measure.....                                   | 84  |
| Figure 19 – Importance Rating, Combined Results of all 5-Stakeholder Groups.....   | 90  |
| Figure 20 –Mechanical System Technical Importance Ratings, Combined Results.....   | 94  |
| Figure 21 – Electrical System Technical Importance Ratings, Combined Results.....  | 97  |
| Figure 22 – Plumbing System Technical Importance, Combined Results .....   | 98  |
| Figure 23 – Overall Building Envelope Technical Importance Ratings, Combined Results of all 5-<br>Stakeholder Groups ..... | 100 |
| Figure 24 – Facility Managers Vs. Designers, Technical Importance of Electrical System Retrofits.....                      | 111 |

|  |     |
|--|-----|
| Figure 25 – Importance Rating, Facility Managers versus Designers .....  | 117 |
| Figure 26 – Importance Rating, Tenant versus Owner .....   | 121 |
| Figure 27 - HOQ for Sustainability Considerations, Equal Representation of All Stakeholder Groups ....   | 126 |
| Figure 28 – Technical Targets Matrix, Sustainability Considerations .....  | 127 |
| Figure 29 – Sustainability: The Common Ground (adapted from Savitz and Weber 2006) .....   | 129 |
| Figure 30 – HOQ Technical Importance, Impact of Stakeholder Requirements on Social Considerations<br>.....   | 131 |
| Figure 31 – HOQ Technical Importance, Impact of Stakeholder Requirements on Environmental<br>Considerations .....  | 131 |
| Figure 32 – HOQ Technical Importance, Impact of Stakeholder Requirements on Economic<br>Considerations .....   | 132 |
| Figure 33 – Tenant HOQ.....  | J-2 |
| Figure 34 – Owner HOQ.....   | J-3 |
| Figure 35 – Facility Manager HOQ .....   | J-4 |
| Figure 36 – Designer HOQ.....  | J-5 |
| Figure 37 – Environmental Compliance Manager HOQ.....  | J-6 |
| Figure 38 – HOQ for Technical Considerations, Equal Stakeholder Group Representation. As seen in<br>Figure 14, provided once again for the purpose of the following sample calculations..... | J-7 |

## List of Tables

|   |     |
|---|-----|
| Table 1 – Driving Forces For Greening Existing Buildings, U.S. and Canada, 2010 to 2014, Ranked in Order of Importance (Adopted from Yudelso n 2010). .....           | 7   |
| Table 2 – Green Building Retrofit Market - Market Barriers / Inhibitors Ranked in Order of Impact (U.S. and Canada), 2010 - 2014 (Adopted from Yudelso n 2010). ..... | 10  |
| Table 3 – Motivations for Pursuing Sustainable Retrofits as Discussed in Literature.....  | 20  |
| Table 4 – Summary of Research Implications and Methodologies for Sustainable Retrofits in Existing Buildings.....   | 21  |
| Table 5 – HOQ Limitations in AEC Industry Applications.....   | 33  |
| Table 6 – Case Study Building Characteristics.....  | 66  |
| Table 7 – Case Study Stakeholders.....  | 71  |
| Table 8 – Stakeholder Requirements: Category I – save costs, save energy, comply with policy, typically associated with owners .....                                  | 103 |
| Table 9 – Stakeholder Requirements: Category II – Enhanced Building Environment for the Tenants ..  | 104 |
| Table 10 – Stakeholder Requirements: Category III – Not Most Important, “Middle of the Road” .....  | 106 |
| Table 11 – Stakeholder Requirements: Category IV – Not Applicable to the Federal Government .....   | 108 |
| Table 12 – Facility Managers and Designer Comparison: Electrical System Technical Importance, Cost, Energy, and Policy .....  | 112 |
| Table 13 – Facility Manager and Designer Comparison: Electrical System Technical Importance, Tenant Oriented Requirements .....                                       | 113 |
| Table 14 – Technical Targets Matrix, Comparison of Stakeholder Ranking.....   | 115 |
| Table 15 – Facility Managers and Designer Comparison: Importance Ratings – Cost, Energy, and Policy .....   | 118 |
| Table 16 – Facility Manager and Designer Comparison: Importance Ratings – Tenant Oriented Requirements .....  | 118 |
| Table 17 – Tenant and Owner Comparison, Importance Ratings – Cost, Energy, and Policy .....   | 122 |
| Table 18 – Tenant and Owner Comparison, Importance Ratings – Tenant Oriented Requirements.....  | 122 |
| Table 19 – 3 <sup>rd</sup> Quartile Comparison, Impact of Stakeholder Requirements on Sustainability Considerations.....  | 132 |
| Table 20 – Importance Rating Data: HOQ Survey Individual Participant Responses.....   | B-2 |

|   |     |
|---|-----|
| Table 21 – HOQ Importance Rating Summary and Data Analysis Calculations .....   | B-3 |
| Table 22 – Pooled Variance t-Test for Two Independent Populations: Tenant and Owner .....                                   | B-4 |
| Table 23 – Pooled Variance t-Test Results for Two Independent Populations: Facility Managers and Designers.....             | B-5 |
| Table 24 – Mechanical System Retrofits, Relationship Rating Survey Data: HOQ Survey Individual Participant Responses .....  | C-2 |
| Table 25 – Mechanical System Technical Importance Calculations: Results for each Individual Participant .....               | C-3 |
| Table 26 – Mechanical System Technical Importance Rating Summary and Data Analysis Calculations, by Stakeholder Group ..... | C-4 |
| Table 27 – Electrical System Retrofits, Relationship Rating Survey Data: HOQ Survey Individual Participant Responses .....  | D-2 |
| Table 28 – Electrical System Technical Importance Calculations: Results for each Individual Participant .....               | D-3 |
| Table 29 – Electrical System Technical Importance Rating Summary and Data Analysis Calculations, by Stakeholder Group ..... | D-4 |
| Table 30 – Pooled Variance t-Test Results for Two Independent Populations: Facility Managers and Designers.....             | D-5 |
| Table 31 – Plumbing System Retrofits, Relationship Rating Survey Data: HOQ Survey Individual Participant Responses .....    | E-2 |
| Table 32 – Plumbing System Technical Importance Calculations: Results for each Individual Participant .....                 | E-3 |
| Table 33 – Plumbing System Technical Importance Rating Summary and Data Analysis Calculations, by Stakeholder Group .....   | E-4 |
| Table 34 – Building Envelope Retrofits, Relationship Rating Survey Data: HOQ Survey Individual Participant Responses .....  | F-2 |
| Table 35 – Building Envelope Technical Importance Calculations: Results for each Individual Participant .....               | F-3 |
| Table 36 – Building Envelope Technical Importance Rating Summary and Data Analysis Calculations, by Stakeholder Group ..... | F-4 |
| Table 37 – Social Considerations, Relationship Rating Survey Data: HOQ Survey Individual Participant Responses.....         | G-2 |

|  |     |
|--|-----|
| Table 38 – Social Considerations Technical Importance Calculations: Results for each Individual Participant .....                      | G-3 |
| Table 39 – Social Considerations Technical Importance Rating Summary and Data Analysis Calculations, by Stakeholder Group .....        | G-4 |
| Table 40 – Environmental Considerations, Relationship Rating Survey Data: HOQ Survey Individual Participant Responses .....            | H-2 |
| Table 41 – Environmental Considerations Technical Importance Calculations: Results for each Individual Participant .....               | H-3 |
| Table 42 – Environmental Considerations Technical Importance Rating Summary and Data Analysis Calculations, by Stakeholder Group ..... | H-4 |
| Table 43 – Economic Considerations, Relationship Rating Survey Data: HOQ Survey Individual Participant Responses .....                 | I-2 |
| Table 44 – Economic Considerations Technical Importance Calculations: Results for each Individual Participant .....                    | I-3 |
| Table 45 – Economic Considerations Technical Importance Rating Summary and Data Analysis Calculations, by Stakeholder Group .....      | I-4 |
| Table 46 – Occupant Satisfaction Survey Data and Calculations .....  | K-2 |
| Table 47 – Occupant Satisfaction Survey Participant Information Data .....   | K-7 |

## **Chapter 1: Introduction**

Buildings are responsible for approximately half of the total greenhouse gas (GHG) emissions in the United States and one third of the energy related CO<sub>2</sub> emissions worldwide that have adverse impacts on the global environment, human health, and the economy (EIA 2011). GHG emissions cause and accelerate the global climate change that creates these harmful impacts for future generations; therefore, the growth of GHG emissions must be slowed and reversed to eliminate this barrier to sustainable development. In addition, natural resources such as air, water, soil, ozone, and non-renewable GHG producing energy sources such as oil, natural gas, and coal are rapidly being depleted. Therefore, implementing resource efficient technologies and improvements in the building sector alone is an economic, social, and environmental necessity that will significantly contribute to mitigating the global climate change problem. Building construction, operations, and the activities that take place inside of them are the major sources for the global demand for energy and the materials whose production results in GHG emissions and the depletion of our non-renewable resources. In fact, activities in buildings consume up to 70 percent of the total electricity produced in the US, use 14 percent of non-industrial water, and generate 40 percent of the non-industrial waste (Yudelson 2010).

Approximately 80 percent of the energy consumed throughout a building's lifecycle occurs after the construction phase, when the building is occupied and in use. This fact implores the industry to produce more resource-efficient buildings and renovate existing stocks according to modern sustainability criteria (UNEP-SBCI 2007). Buildings typically have long service lives that range from 30 to 70 years or more, making the spread of technological innovation a slow process (Poel 2007; Lemer 1996). However, the US Energy Information Administration estimates that by the year 2035, approximately 75 percent of the aging built environment will be

either new or will undergo a major renovation. This transformation over the next 23 years represents a historic opportunity for the building stakeholder community to make significant contributions to the global demand for resources.

It is important to recognize that approximately 86 percent of building construction expenditures relate to the renovation of existing buildings (Holness 2008). In addition, a study of the US green building retrofit industry in 2009 indicated that there is a significant growth in the market to sustainably retrofit existing buildings that is projected to dramatically increase in the next 25 years (Bernstein and Russo 2009). Therefore, the existing non-residential building stock is a key target for energy efficient interventions to substantially reduce adverse impacts to the environment, human health, and the economy. Furthermore, Federal government buildings form a significant portion of the building stock in the US and are a prime candidate for demonstrating the many benefits of sustainable retrofit measures for the privately owned building community. More specifically, the Department of Defense (DoD) is the largest single user of energy in the US, consuming 0.8% of total US energy and 78% of Federal government energy (DoD 2008). Approximately 70% of the DoD electricity use is consumed by its facilities, and the DoD owns over 207,000 buildings with over 1.6 billion square feet of floor space and a \$4 billion dollar annual energy bill (DoD 2008; DoD 2009).

This compelling and important role that existing government buildings will play in achieving energy reductions is emphasized and guided by the most recent US Federal legislation. Executive Order (EO) 13423 was issued by the President of the US in 2007 requiring “Federal Leadership in High Performance and Sustainable Buildings” with particular emphasis on strengthening the environmental, energy, and transportation management of federal owned building facilities by implementing the general guidelines of the Energy Policy Act of 2005.

Furthermore, the policy provides guidance to all federal agencies to reduce the energy consumption by 30 percent as compared to the 2003 baseline and incorporate sustainable practice in 15 percent of the existing building inventory (EO 13423 2007). To demonstrate this commitment, the 2009 American Recovery and Reinvestment Act (ARRA) included many provisions encouraging investment in energy efficient improvements in buildings, with a primary focus on existing buildings. As a result, approximately \$26 to \$30 billion were allotted to a number of federal agencies including the US General Service Administration (GSA), the Department of Energy (DOE), the Department of Defense (DOD), and the Department of Housing and Urban Development for energy efficient upgrades to their existing facilities (ARRA 2009). In 2011, The White House published the “Blueprint for a Secure Energy Future” that includes strategies for programs that build on ARRA to leverage public dollars to encourage private sector energy efficiency investments in their existing building stocks (White House 2011). As a result of these policies to provide for secure, clean, and safe energy supplies for the sustainment of future generations; organizations have been dedicating substantial portions of their building operations and maintenance budgets for the sole purposes of reducing energy and resource consumption.

Existing buildings provide a unique opportunity for sustainable retrofit over the life cycle of a building that is different than the regular maintenance and necessary repairs that arise during building operations. For example, aging building equipment can be replaced instead of continuously repaired, extending the life span of a building and preventing the early onset of obsolescence. Continuous maintenance is only a short-term solution to the larger problem of an aging building in terms of reducing energy consumption and carbon footprint of a building; resulting in increased costs and diminishing returns for the building stakeholders, and ultimately, abandonment of the building (Tainter 1995, Poel 2007). On the other hand, sustainable retrofit is

a capital improvement with an associated cost that resets the building life, improves performance, and makes the building's use more predictable for an extended period of time (Allen 2001). Retrofit is also an engineering solution that actively engages stakeholders and uses life cycle thinking in its development (Abraham and Nguyen 2004).

However, maximizing energy savings while ensuring project profitability is often the most challenging aspect for the building stakeholders and this challenge often results in overlooking more than 50 percent of possible energy savings methods (Schneider and Rode 2010). Many energy efficient possibilities have not been realized due to characteristics in the markets, technologies, and end-users; all of which inhibit rationale, energy-saving choices during the life cycle of a building (UNEP-SBCI 2007). Therefore, aligning stakeholders' requirements for enhanced work environments, profit maximization, and energy savings, among others, while choosing sustainable retrofit measures, is a fundamental challenge that needs to be addressed if the targeted reduction in greenhouse gas emissions is to be achieved. This emphasizes the critical need for a framework that studies the relationship between the social, environmental, economic, and technical aspects of the retrofit process, and identifies optimal retrofit measures that save energy, reduce GHG emissions, and deliver enhanced environments for all building stakeholders. In order to establish how to model these requirements and influences to make better informed decisions, we must first understand how the various requirements of the different building stakeholders affect the sustainable retrofit decision and to what extent are those requirements influenced by social, environmental, economic, and technical considerations.

This research presents a unique effort to investigate the challenges and barriers in meeting the various project requirements of the different types of building stakeholders, and the effect of those requirements on the decision to sustainably retrofit an existing building. This

study is the first step towards exploring the interactions between the building stakeholders, environmental impacts, economic constraints, and perceived retrofit measures to develop a decision support framework to achieve sustainably effective retrofits in existing buildings. Through survey design and analysis methodologies, the hierarchy of stakeholder requirements and how the stakeholder type affects the ranking of those requirements will be determined. These factors will be determined relative to stakeholder perceptions concerning four main technical categories of sustainable retrofits; namely, the mechanical, electrical, plumbing, and building envelope systems. Furthermore, this research will also attempt to translate the requirements and influences of the stakeholders in sustainable retrofit decision making into technical focus areas for a case study building with a novel approach that utilizes the House of Quality (HOQ), the main tool from Quality Function Deployment. This new way of applying the HOQ to an Architecture, Engineering, and Construction (AEC) industry application will be illustrated through a case study involving a Department of Defense commercial building and its stakeholders.

## **Chapter 2: Literature Review**

### *2.1 – Motivations for the Pursuit of Sustainable Retrofits*

Researchers have studied the motivations of public and private building owners in their pursuit of green and sustainable building design initiatives. An example to illustrate this increase in interest is the growth in the number of applications to the US Green Building Council's (USGBC) Leadership in Energy and Environmental Design (LEED) certification process. The number of certifications has grown tremendously since it was first developed in March 2000 with more than 40,000 projects either certified or in the certification process, representing 7.9 billion square feet of construction space in 50 states and 117 countries (Christ and Furness, 2011). In addition, in 2007 a significant shift in growth from LEED certification for new construction to that for existing buildings was observed, in which the rate of growth in LEED for Existing Building certification more than doubled the rate in growth for all other certification programs (Yudelson 2010).

Yudelson (2010) outlined multiple reasons why building owners and operators are utilizing these guidelines to develop energy efficient and sustainably retrofitted buildings. The primary factors include growing tenant demand to lower operating costs associated with electricity, fuel, and water consumption, higher employee productivity, investors seeking more socially conscious investments, and reputational issues that have been forcing the real estate sector towards more efficient building techniques. Table 1 shows some of the primary reasons for implementing sustainable retrofits in existing buildings based on the author's judgment (Yudelson 2010).

**Table 1 – Driving Forces For Greening Existing Buildings, U.S. and Canada, 2010 to 2014, Ranked in Order of Importance (Adopted from Yudelson 2010).**

| DRIVING FORCE  | COMMENTARY   | RELATIVE IMPORTANCE |             |
|--|--|---------------------|-------------|
|  |  | 2010 – 2011         | 2012 - 2014 |
| 1. Tenant Demand                                     | Tenants are increasingly demanding LEED-certified buildings  | Medium              | High        |
| 2. Attractive return on investment                   | Many energy retrofits and LEED-EB certifications are showing high rates of return on investment for owners                           | High                | High        |
| 3. Responsible property investing                    | Investors and owners committed to corporate social responsibility are asking for LEED buildings                                      | Low                 | Medium      |
| 4. Future competitiveness                            | Owners with longer-term perspective are concerned that their properties' attractiveness might diminish                               | Medium              | High        |
| 5. Stakeholder pressure                              | Employees, investors, tenants, and communities want green buildings  | Low                 | Medium      |
| 6. Corporate sustainability                          | Building owners see investing in sustainable measures as an important way to occupy a leadership position                            | Low                 | High        |
| 7. Concern about energy prices and future volatility | Energy is the largest cost of building operations and the least controllable. Future price increases could easily outstrip inflation | Medium              | Medium      |

In addition to these owner and tenant driven reasons, public policy has pushed building construction towards sustainable and green design through stricter building codes and regulations. For example, having recognized the advantages of green buildings, national governments and the European Union (EU) have mandated higher efficiency standards for new construction and renovations as stipulated in the EU Energy Performance of Buildings Directive (EPBD) of 2002. EPBD 2010, the follow-up directive, is likely to make “near-zero” energy buildings mandatory by 2021 (Poel et al. 2007).

Fuerst and McAllister (2009) also researched the rationale to pursue green and sustainable building design. Their study discovered a rental premium and/or lower vacancy rates for environmental and sustainable certified buildings. They also determined that investors were able to receive higher net operating income due to increased demand from tenants, lower costs of ownership primarily associated with energy and other utilities savings, as well as an element of protection from future regulatory changes. In fact, their empirical analysis confirmed that there

is a rental premium (cost per square foot) of approximately five percent for LEED certification and four percent for Energy Star.

## *2.2 – Barriers to the Implementation of Sustainable Retrofits*

A number of studies in the US indicate that there is a significant market demand for sustainable buildings which resulted in a dramatic increase in the number of new buildings that pursue Leadership in Energy and Environmental Design (LEED) certification, with an estimated 2 billion of certified commercial building square footage in 2010 (USGBC 2012). However, sustainable building retrofit projects are still not as widely pursued for several reasons including: lack of information about the building and its systems after the design phase (Bosch and Pearce 2003), reluctant stakeholder commitment because energy costs are not high enough to create a strong incentive for retrofits (Beheiry et al. 2006), and perceptions that significantly higher initial investment costs outweigh economic and environmental benefits (Scofield 2009).

Bosch and Pearce (2003) presented an analysis of nine sustainable design and construction guidance documents used by public schools that were created to educate facilities decision makers in regards to sustainable design and construction practices. Their analysis concluded that efforts were focused on designers and owners and that much less information was targeted to other important building stakeholders that were identified in their research such as facilities managers. According to Bosch and Pearce (2003), facilities managers play an important role in ensuring sustainably designed facilities continue to operate as intended after construction is complete, and information is missing from sustainable design and construction guidance documents for the use of facilities managers and other stakeholders such as government representatives, community members, contractors, utility providers, and financiers (Bosch and Pearce 2003).

Beheiry et al. 2006 conducted a study to evaluate the relationship between two corporate sustainability reporting indices and the impact of a corporate commitment to sustainability on project planning, performance, and cost. At the time of the study, the authors felt that there is still great uncertainty amongst the public and business community about the social and economic aspects of sustainable development, and that the emphasis on the environmental aspect of sustainability needs to be complimented with greater emphasis in these two areas. There is still much skepticism concerning the investment of business resources in analyzing social impacts and economic development resulting from a corporate commitment to sustainability, outside of the sustainable project's individual return on investment (ROI). The authors concluded that corporate reporting adds value that compliments other forms of business operations analysis, and that these indices should be further developed in order to allow corporations to better allocate their resources and achieve a balance between sustainable practices, financial returns, and future uncertainties (Beheiry et al. 2006).

In 2009 an analysis was completed to address misconceptions that LEED buildings are energy efficient buildings. Earlier studies indicated that LEED-certified buildings use 18-39% less energy than their conventional counterparts, however, according to Scofield (2009), these analysis were skewed and created misconceptions. The results of this analysis concluded that LEED-certified commercial buildings, on average, show no significant primary energy savings over comparable non-LEED buildings and therefore, are not delivering a reduction in greenhouse gas emissions (Scofield 2009). This finding combined with the additional costs required for certifying a building as LEED diminishes the value of sustainable development for several stakeholders creating the perception that there are higher costs associated with sustainable development that outweigh the environmental and social benefits.

These barriers inhibit the existing building community from implementing sustainable retrofits, reduce the growth rate of new sustainable retrofit projects, and therefore make sustainable retrofits more costly. In a survey by Yudelson (2010), real estate executives rated higher construction costs, long payback periods, and the difficulty in quantifying benefits as the biggest obstacles to green construction. Yudelson (2010) also illustrated some of the primary barriers for implementing sustainable retrofits, which can be seen in Table 2.

**Table 2 – Green Building Retrofit Market - Market Barriers / Inhibitors Ranked in Order of Impact (U.S. and Canada), 2010 - 2014 (Adopted from Yudelson 2010).**

| INHIBITING FORCE OR BARRIER                                     | COMMENTARY  | RELATIVE IMPORTANCE |             |
|---|---|---------------------|-------------|
|   |   | 2010 – 2011         | 2012 – 2014 |
| 1. Divergence between capital outlays and operating budgets     | Many organizations tend to skimp on capital outlays that will improve operating results, even putting them in different budget categories, especially in the public sector. | High                | Medium      |
| 2. Split incentives between tenants and landlords               | Triple net leases prevalent in the United States and Canada reduce landlord incentive to invest in energy savings that will benefit tenants.                                | High                | Medium      |
| 3. Perceived costs far outweigh benefits                        | Perceptions from early green buildings of significantly higher costs vs. tangible benefits.   | Medium              | Low         |
| 4. Benefits of energy investments not proven                    | Even if tenants want to reduce energy costs, there's little proof that base building measures will do that.   | Medium              | Low         |
| 5. Incentives are not strong enough to change behavior          | Energy prices are still low and tax and other political incentives are not significant enough to change behavior across the nation.   | High                | Medium      |
| 6. Lack of debt financing for energy upgrades                   | Most building owners must borrow money to finance energy upgrades that have more than a one-year payback.   | High                | Medium      |
| 7. Energy costs vary widely across the United States and Canada | Energy prices vary by a factor of two to four, depending on location, making it hard to incentivize and justify on a national basis.  | Medium              | Medium      |
| 8. Organizational dynamics                                      | Getting buy-in from everyone in the organization is often difficult.  | Medium              | Low         |

### *2.3 – Conflicting Stakeholder Requirements*

Existing building stakeholders play an important role in determining what sustainable retrofits are implemented and when. Building stakeholders in this context are defined as the people who directly or indirectly have a vested interest in the building, its operation, and the outcome of a future retrofit project. Building stakeholders include, but are not limited to, the owner, tenants, investors, building operator, and the designers. Furthermore, stakeholder categories such as the tenants consist of various parties with different interests in the building such as management, staff, or guests. These building stakeholders have varying and in most cases conflicting perspectives on how, when, and why a building should be sustainably retrofitted (Yudelson 2010; Bernstein and Russo 2009). For example, the owner of an existing building might be motivated to sustainably retrofit to reduce life cycle costs, and increase return on the investment. On the other hand, the tenant is interested in lower transaction costs with no upfront capital, and clear incentives such as lower rent or increased employee productivity. Other important issues arise when the owner feels that they are paying for the improvements in the building, but the tenants are reaping most of the benefits, such as reduced energy costs. This situation is further aggravated in multi-tenant buildings where participation from nearly all tenants, each with their own set of requirements, is necessary to achieve the stated objectives of the sustainable retrofit plan.

Several studies demonstrate that conflicting and opposing stakeholder requirements is one of the main barriers that limits the increase in the number of sustainably retrofitted buildings, and that a decision making framework to align the various requirements is necessary in order to develop an acceptable solution. Rey (2004) proposed a multi criteria assessment methodology for existing building retrofit strategies which simultaneously takes environmental, social, and

economic criteria into account to support the decision making process. The authors concluded that beyond the economics of building performance, other elements related to a building's specific use by varying stakeholders have great importance in the choice of the most suitable retrofitting strategy. These other elements require greater collaboration from stakeholders that often render energy efficient technical solutions, such as natural ventilation and passive cooling, unacceptable in certain situations. In addition, it was also concluded that the impact of certain economically desirable and technically feasible retrofit solutions result in less acceptable social and environmental impacts when taking the architectural quality and historical value of an existing building into account. Sustainable retrofit provides an opportunity to fully optimize the benefits that a building provides, and integrated approaches need to be further developed in order to synthesize opposing stakeholder requirements while reducing energy consumption, improving occupant comfort, and mitigating environmental impacts (Rey 2004).

Sustainable retrofit projects involve complex processes that are typically unfamiliar to some stakeholders. In studying Lean processes for sustainable building delivery, Lapinski et al. (2006) noted that facilities owners and project teams often struggle to implement sustainable requirements, and as a result, incur additional project costs or even defer the investment altogether. The study noted that sustainable building projects require a much higher level of interdisciplinary collaboration amongst unique stakeholder groups starting at the beginning of the capital planning process. The research also added that considering the environment as a stakeholder, or additional customer, generated value by fulfilling the interwoven needs of both the end user and environment, such as a healthy and productive occupant environment with minimal building impact. The authors attributed part of the reason for difficulties in implementing sustainable buildings to the limited understanding of the importance of activities that engage various stakeholders in sustainable projects and to decision making processes that

are unresponsive to the needs of all stakeholders. Many building owners and project teams make mistakes early as a result of inexperience with the unique and challenging requirements of sustainable buildings; therefore, early selection of an integrated team with experience in sustainable project delivery and the investment of time to align the project goals of all stakeholders clearly define the success for a project (Lapinski et al. 2006).

Klotz and Hormon (2010) described the application of counterfactual analysis in sustainable project delivery processes to assist with increasing process transparency amongst all project stakeholders in order to decrease sustainable project costs. The authors concluded that the method of counterfactual analysis, with roots in economics, history, and political science, was well suited for the complex process of sustainable building delivery that requires a higher degree of stakeholder interaction. The study illustrated that the delivery of a sustainable buildings requires increased coordination amongst a variety of groups such as construction professionals, designers, engineers, facilities managers, occupants, and utilities companies; all having varying project requirements, different levels of familiarity with the process, and each in possession of valuable information that other parties may not even know that they need in order to maximize project performance. Furthermore, the study confirmed that sustainable building features such as optimum lighting and improved indoor environmental quality and the subsequent outcomes of increased employee productivity and improved health are enhanced when stakeholders cooperate, although the impacts are difficult to quantify (Klotz and Hormon 2010). The impacts of sustainable buildings on social, environmental, and economic considerations is understated and the understanding of different stakeholder requirements is necessary to provide transparency in and enhance decision making in this area.

## *2.4 – Implication of Sustainable Development and Decision Making*

A considerable amount of research has investigated technical, economic, and environmental implications of existing building retrofits and a number of decision support methodologies have been proposed. From an economic perspective, the decision to sustainably retrofit an existing building faces several challenges such as demonstrating achievement while still respecting budget and schedule constraints, addressing occupant resistance to change, meeting corporate constraints on activities, and finding attractive investment and debt capital for energy upgrades (Yudelson 2010). In addition, most existing retrofit measures focus on relative or predicted performance of buildings without set benchmarks for assessing the adequacy of the chosen methods in terms of actual energy savings (Entrop et al. 2010). This increases the uncertainty surrounding the expected benefits from any investment in sustainable retrofits, and forces building stakeholders to postpone investment until more proven returns are available (Mckinsey and Company 2008). Moreover, the decision to sustainably retrofit is most often made based on purely economic grounds without taking into account the environmental impacts of this decision.

### *2.4.1 – Uncertainties in Energy Pricing and Climate Change*

Papadopoulos et al. (2002) completed a study to identify the feasibility of potential energy saving renovation measures under uncertain energy pricing policies and conditions for both residential and commercial buildings, public and private, in Greece. The authors noted that although certain technologies, such as individual split heat pump air conditioning units, might make sense for the tenants from an economical perspective due to underpriced energy policies, these technologies present serious problems for the national economy and the environment. At the time, Greek policies were focusing on obtaining less expensive forms of energy, rather than

focusing on the reduction of energy and CO<sub>2</sub> based emissions. These policies were only prolonging the inevitable investment for energy efficiency upgrades to existing buildings, while continuing to operate at high costs and environmental impacts. The study concluded that there was potential for an average savings of 28% in building envelope upgrades; however, the most important message from this research was that the environmental impact of failing to upgrade the existing building stock is much too important to overlook regardless of economic paybacks (Papadopoulos et al. 2002). This research presented a unique perspective regarding the complexity of various stakeholder concerns with regards to short-term policies.

In 2005 Gaterell and McEvoy completed a study to include the consequences of social and environmental impacts due to climate change in the decision-making process for initiating energy efficient retrofits in residential homes in the United Kingdom (UK). It was found that the current investment decisions for energy efficient housing enclosure refurbishments based on normal market energy prices and today's climate is likely to deliver solutions that will remain effective regardless of future uncertainties in climate change and market prices. This indicates that a decision made today based on purely economic grounds regarding the payback for energy savings techniques will still have a significant impact on social, environmental, and economic concerns for future generations (Gaterell and McEvoy 2005).

#### *2.4.2 – Decision Making Methodologies*

Much of the latest research has focused on translating the difficult to quantify long-term benefits into economic metrics for decision making. Juan et al. (2010) developed an efficient integrated decision support system to assess existing office building sustainability conditions and recommend an optimal set of sustainable retrofit measures that considers the trade-offs between cost, resource consumption, energy performance, and CO<sub>2</sub> emissions. The model advanced the

decision making process by introducing advantages in solutions satisfaction. They determined that researchers should be more concerned with energy-efficient renovation strategies that minimize environmental impacts and consider existing conditions, in addition to energy consumption simulation and prediction (Juan et al. 2010).

Chidiac et al. (2010) developed a methodology to rank the energy savings potential for a large set of Canadian office building stock and select the optimum energy savings measures to adopt for each building. The focus of this research was on the performance of four energy retrofit measures in the categories of mechanical, electrical, and building envelope, and their economic paybacks. The use of energy modeling software was used in combination with regression analysis and energy savings payback calculations when analyzing energy retrofit measures for lighting, insulation, and boiler retrofits. The study demonstrated that this decision-making technique was effective in calculating the overall rate of return for each potential energy retrofit investment and that age, geographic location, and size of each unique building influence the effectiveness of the different energy retrofit measures being considered (Chidiac et al. 2010).

Entrop et al. (2010) investigated energy performance indicators in Dutch residential dwellings and developed a methodology that incorporated additional revenues within the financial analysis of energy saving techniques. The research incorporated a long-term financial gain as a benefit for pursuing sustainable retrofits into the decision-making process. The study revealed that much shorter payback periods in ROI methodologies could be achieved by including the indirect benefits derived from an increase in property value due to energy efficiency gains from wall and roof insulation. The willingness of owners and investors to pay for these refurbishments could be enhanced by including long-term and indirect economic benefits, such as an increase in property value, in a life cycle cost analysis.

### *2.4.3 – Long Term Social and Environmental Benefits*

These studies have investigated costs and benefits associated with many aspects of implementing sustainable building features; however, several studies have indicated that life cycle cost analysis methods (LCCA) that translate all long-term social and environmental benefits into economic savings and returns do not exist. Therefore, the decision to renovate is often based purely on short-term economic returns for the owner, without taking soft long-term benefits to the environment and society into account. Such benefits may have a future economic return for the owner resulting from an improved image, increased trust, avoided legal costs due to opposition to only name a few (Singer et al. 2007; Savitz and Weber 2006; Gluch and Baumann 2003).

Rather than measuring benefits in economic decision making terms, Nemry et al. (2010) analyzed the environmental impact from European residential buildings from a life cycle perspective, from construction through demolition, by measuring global warming potential (i.e., CO<sub>2</sub> emissions and energy usage). The main technical improvement options related to a building's potential for environmental impact reduction were identified and the effectiveness of these options was assessed. Methods to reduce heat loss such as wall insulation, roof insulation, and wall or roof penetration sealants were evaluated to have the ability to reduce the environmental impact by as much as 20 percent with a significant savings in CO<sub>2</sub> emissions. Another interesting finding was that although buildings in colder climates consumed much more energy due to heating demands than buildings in moderate climates, buildings in colder climates were found to be much more energy efficient when normalized to similar weather conditions (Nemry et al. 2010). These findings illustrate that different building stakeholders (e.g. owners, occupants, designers...) have different building performance requirements, that energy efficient

features may not have enough known payback to justify the investment in certain situations, and that the decision for which sustainable retrofit measures should be implemented and when are dependent on the individual situation of each building.

## *2.5 – Summary of Literature Review*

There are multiple reasons why stakeholders, or anyone with a vested interest in a building, are concerned with increasing the sustainability of their buildings from social, environmental, economic, and technical perspectives. In most cases, these building stakeholders have varying and opposing perspectives on how, when, and why a building should be sustainably retrofitted. In addition, several studies indicate that conflicting stakeholder requirements are a main barrier in implementing sustainable retrofits; and therefore, they are not pursued for many reasons including a lack of understanding of complex sustainable retrofit processes, concerns about uncertainty in economic paybacks, and perceptions that long-term social and environmental benefits will not be achieved (Scofield 2009; Lapinski et al. 2006; Gaterell and McEvoy 2005). The motivations and barriers behind public and private building owners in their pursuit for sustainable building design has been discussed and explored in many publications (Fuerst and McAllister 2009; Poel et al. 2007, Beheiry et al. 2006; Bosch and Pearce 2003); however, few studies have explored the interaction between the many stakeholders and their different requirements on the decision to implement sustainable retrofits in existing buildings.

This extensive literature review revealed the primary stakeholder requirements for implementing sustainable retrofits in existing buildings and guided the formulation of the research objectives presented in Chapter 3 and the methodology presented in Chapter 4. These requirements are summarized in Table 3 on page 20. The stakeholder requirements are all motivations that can be attributed to each of the four categories of social, environmental,

economic, and technical implications. The primary implications as discussed in literature are denoted in Table 3 and most benefits can be translated to economic returns through discussion; however, many social and environmental long-term and soft benefits are difficult to quantify in economic terms (Juan et al. 2010; Rey 2004).

Furthermore, technical, economic, and environmental implications of existing building retrofits have been explored in several studies. This substantial amount of research has provided a significant basis into the economic and environmental impacts of sustainable retrofit measures in existing buildings (Chidiac et al. 2010; Entrop et al. 2010; Juan et al. 2010; Nemry et al. 2010; **Gaterell and McEvoy 2005**; Gluch and Baumann 2003; Papadopoulos et al. 2002). However, most of these initiatives have focused only on technical aspects of retrofits in countries other than the US where climate, energy prices, and existing building stock characteristics are different. In addition, most studies did not take into account the important role that different building stakeholders play in determining the type and extent of any retrofit measures, or develop methodologies to enhance the interaction amongst these stakeholders.

Research has indicated that the decision to sustainably retrofit is most often made based purely on short-term economic grounds without taking into account the long-term social and environmental impacts of the decision that are difficult to quantify. Researchers have developed several beneficial decision making frameworks to facilitate the process of selecting energy and water efficient measures; however, a framework that illustrates the long-term environmental and economic benefits for all stakeholders does not yet exist (Yudelso 2010; Oreszcyn and Lowe 2010). A summary of methodologies that researchers have developed and that have been reviewed in this section are shown in Table 4 on 21, and these studies guided the formulation of the research objectives presented in Chapter 3.

**Table 3 – Motivations for Pursuing Sustainable Retrofits as Discussed in Literature**

| Perceived Benefits<br>(Stakeholder Requirements) | Social | Environment | Economic | Technical | Sources:  |
|--|--------|-------------|----------|-----------|---|
| Increase return on investment (ROI)              |        |             | X        |           | Chidiac et al. 2010; Entrop et al. 2010; Juan et al. 2010; Yudleson 2010; Beheiry et al. 2006; Gaterell and McEvoy 2005<br>Rey 2004; Papadopoulos et al. 2002   |
| Achieve lower total ownership costs              |        |             | X        |           | Chidiac et al. 2010; Entrop et al. 2010; Juan et al. 2010; Yudleson 2010; Fuerst and McAllister 2009; Scofield 2009; Bosch and Pearce 2003                      |
| Lower project capital costs                      |        |             | X        |           | Entrop et al. 2010; Juan et al. 2010; Yudleson 2010; Fuerst and McAllister 2009; Scofield 2009; Bosch and Pearce 2003   |
| Reduce energy costs                              |        |             | X        |           | Juan et al. 2010; Scofield 2009; Rey 2004; Papadopoulos et al. 2002   |
| Increase property value                          | X      |             | X        |           | Entrop et al. 2010; Yudleson 2010; Bernstein and Russo 2009   |
| Achieve higher rental rates                      |        |             | X        |           | Yudleson 2010; Bernstein and Russo 2009; Fuerst and McAllister 2009   |
| Achieve higher occupancy rates                   |        |             | X        |           | Yudleson 2010; Bernstein and Russo 2009; Fuerst and McAllister 2009   |
| Avoid costs due to opposition                    | X      |             | X        |           | Singer et al. 2007; Savitz and Weber 2006; Gluch and Baumann 2003   |
| Improve occupant productivity                    | X      |             | X        |           | Klotz and Hormon 2010; Yudleson 2010; Bosch and Pearce 2003   |
| Improve corporate reporting results              | X      |             | X        |           | Yudleson 2010; Singer et al. 2007; Beheiry et al. 2006; Savitz and Weber 2006; Gluch and Baumann 2003   |
| Improve your organization's image                | X      |             | X        |           | Yudleson 2010; Singer et al. 2007; Savitz and Weber 2006; Gluch and Baumann 2003  |
| Gain the public's trust                          | X      |             | X        |           | Yudleson 2010; Bernstein and Russo 2009; Singer et al. 2007; Savitz and Weber 2006; Gluch and Baumann 2003  |
| Reduce chance of opposition                      | X      |             |          |           | Singer et al. 2007; Savitz and Weber 2006; Gluch and Baumann 2003   |
| Improve aesthetic quality of site                | X      | X           |          |           | Bernstein and Russo 2009; Rey 2004; Singer et al. 2007  |
| Decrease outages / interruptions                 | X      |             | X        | X         | Klotz and Hormon 2010; Yudleson 2010  |
| Attract and retain employees                     | X      |             | X        |           | Yudleson 2010; Bosch and Pearce 2003  |
| Improve occupant attendance                      | X      |             | X        |           | Klotz and Hormon 2010; Lapinski et al. 2006; Rey 2004<br>Bosch and Pearce 2003  |
| Improve occupant comfort                         | X      |             |          |           | Klotz and Hormon 2010; Lapinski et al. 2006; Rey 2004; Bosch and Pearce 2003  |
| Improve occupant health                          | X      |             | X        |           | Klotz and Hormon 2010; Lapinski et al. 2006; Rey 2004<br>Bosch and Pearce 2003  |
| Increase energy efficiency                       |        | X           | X        | X         | Chidiac et al. 2010; Juan et al. 2010; Poel et al. 2007;<br>Rey 2004; Papadopoulos et al. 2002  |
| Reduce energy consumption                        |        | X           | X        | X         | Chidiac et al. 2010; Juan et al. 2010; Nemry et al. 2010; Scofield 2009;<br>Bosch and Pearce 2003; Papadopoulos et al. 2002                                     |
| Provide a secure energy supply                   | X      | X           | X        | X         | Yudleson 2010; Singer et al. 2007; Papadopoulos et al. 2002   |
| Facilitate renewable energy                      | X      | X           | X        | X         | Yudleson 2010; Singer et al. 2007; Papadopoulos et al. 2002   |
| Minimize environmental impact                    | X      | X           |          |           | Juan et al. 2010; Scofield 2009; Beheiry et al. 2006; Lapinski et al. 2006; Gaterell and McEvoy 2005; Rey 2004; Bosch and Pearce 2003; Papadopoulos et al. 2002 |
| Increase carbon neutrality                       | X      | X           |          |           | Juan et al. 2010; Nemry et al. 2010; Scofield 2009; Gaterell and McEvoy 2005; Papadopoulos et al. 2002  |
| Reduce costs of carbon offset                    |        |             | X        |           | Nemry et al. 2010; Yudleson 2010; Papadopoulos et al. 2002  |
| Meet regulatory requirements                     | X      | X           | X        | X         | Fuerst and McAllister 2009; Poel et al. 2007; Papadopoulos et al. 2002  |
| Comply with policy or legislation                | X      | X           | X        | X         | Poel et al. 2007; Papadopoulos et al. 2002  |
| Diversify investment portfolios                  |        |             | X        |           | Yudleson 2010; Fuerst and McAllister 2009; Beheiry et al. 2006  |
| Leverage business platforms                      |        |             | X        |           | Yudleson 2010; Fuerst and McAllister 2009; Beheiry et al. 2006  |

**Table 4 – Summary of Research Implications and Methodologies for Sustainable Retrofits in Existing Buildings**

| <b>Authors</b>           | <b>Focus of decision making methodology</b>   | <b>Building Sector</b>     | <b>Country</b>      |
|--------------------------|---|----------------------------|---------------------|
| Entrop et al. 2010       | Economic and Technical Implications – Indirect benefits such as increased property value on energy savings ROI  | Residential                | Netherlands         |
| Gaterell and McEvoy 2005 | Environmental and Economic Implications – Energy savings ROI and Uncertainty in energy prices vs. effectiveness of retrofit measures.   | Residential                | United Kingdom (UK) |
| Juan et al. 2010         | Environmental, Economic, and Technical Implications – Decision making model - Sustainable Retrofit Strategies to reduce emissions and energy.   | Commercial Office          | Taiwan              |
| Chidiac et al. 2010      | Economic and Technical Implications – Energy modeling and payback predictions (ROI) for retrofit strategies.  | Commercial Office          | Canada              |
| Nemry et al. 2010        | Environmental, Economic and Technical Implications – Energy savings, emissions reductions, and life cycle cost analysis.  | Residential                | Europe (EU-25)      |
| Papadopoulos et al. 2002 | Social, Environmental, Economic, and Technical Implications – Energy savings ROI and Uncertainty in energy prices vs. effectiveness of retrofit measures.   | Residential and Commercial | Greece              |
| Rey 2004                 | Social, Environmental, and Economic Implications – Multi-criteria assessment methodology for retrofit strategies.   | Commercial Office          | Switzerland         |
| Klotz and Hormon 2010    | Social, Environmental, Economic, and Technical Implications – Counterfactual analysis in sustainable project delivery to increase process transparency for stakeholders and decrease project costs. | Commercial University      | US                  |

## Chapter 3: Research Objectives

### 3.1 – Objectives

Integrating the varying requirements of the numerous building stakeholders, while selecting sustainable retrofit measures, represents a significant challenge that must be addressed in order to improve the building environment for all stakeholders, reduce the harmful effects of greenhouse gas emissions, and conserve natural resources to sustain future generations. This challenge is further intensified because sustainable retrofit projects involve more complicated processes than traditional building renovations that are often unfamiliar to some stakeholders. That is why a concise decision making framework that addresses the interactions between the social, environmental, economic, and technical aspects of the sustainable retrofit process is necessary to align stakeholder requirements and determine an optimized solution.

The first step that is necessary in order to establish a decision making framework that models the influences of environmental impact, economic constraints, and technical feasibility is to understand how the requirements of the different building stakeholders affect the sustainable retrofit decision. For this research, the sustainable retrofit decision for a case study building will be divided into four main technical components of the building system: mechanical, electrical, plumbing, and external skin (building envelope – walls, windows, doors, roof, and shading). The literature review presented in Chapter 2 guided and formed the objectives of this research; stated as follows:

- Determine how to model the requirements and influences of the stakeholders in making a decision to implement sustainable retrofits using the House of Quality (HOQ), introduced in the methodology of Chapter 4.

- Determine the main requirements of different building stakeholders for initiating sustainable retrofits from each of the four sustainable retrofit measures considered in this research.
- Determine how the stakeholder type affects the ranking of their requirements for each of the four main technical measures.

## **Chapter 4: Methodology**

### *4.1 – Introduction to the House of Quality*

The literature review conducted in Chapter 2 revealed several barriers that inhibit building stakeholders from making reasonable and effective decisions to sustainably retrofit their existing buildings, and guided the formulation of the research objectives of Chapter 3.

Implementing sustainable retrofits in existing buildings involves a significant amount of planning and communication with numerous stakeholders to obtain a commitment to shared goals and achieve a beneficial solution for all parties involved (Lapinski et al. 2006). Existing building stakeholders determine what sustainable retrofits are implemented and when; however, these stakeholders have contrasting perspectives on how and why a building should be retrofitted (Yudelson 2010; Bernstein and Russo 2009).

Stakeholders such as the tenants, owner, investors, building operator, and architect/engineer are responsible for the retrofit design. However, the owner and investors may be interested in achieving a high return on the capital investment with low operating costs; the tenant is interested in clear incentives such as low rent and increased employee productivity; while the building operator wants easy access, standardization of parts, and training on the updated technology for quick and efficient repairs. Furthermore, the owner may often feel like they are paying for the building upgrades while the tenant is mostly benefiting from reduced energy costs, and the tenant often feels that they are being inconvenienced and losing productivity from the retrofit process that takes place while they are conducting business within the building. That is why a framework that integrates the many stakeholders and their requirements is needed to overcome these barriers and addresses the interactions between the social, environmental, economic, and technical aspects of the sustainable retrofit process.

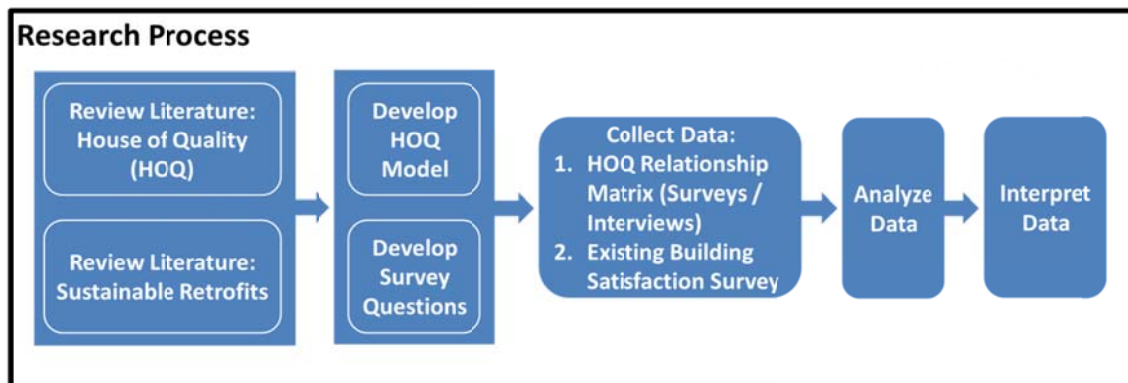
The House of Quality (HOQ), the main tool from Quality Function Deployment (QFD), was selected as a tool that has the power to address the problem of integrating the varying requirements of the numerous building stakeholders, while selecting sustainable retrofit measures, especially when a building is occupied and in use. The HOQ provides a framework to coordinate and maintain priorities amongst all stakeholders involved, and translate those priorities into technical focus areas using a series of two-dimensional matrices and mathematical calculations. The process identifies technical measures that have the highest impact on stakeholder requirements, and then facilitates the prioritization of those technical measures by assigning each a single score for a decision making comparison. (Yang et al. 2003, Kamara and Anumba 2000, Mallon and Mulligan 1993).

For this research the sustainable retrofit decision was divided into four main technical measures of the building: the mechanical, electrical, plumbing, and building envelope (i.e. “exterior skin” - windows, shading, roof, insulation, doors, etc.). Data will be collected and analyzed using the HOQ to establish a correlation between the building stakeholder requirements (independent variables) and each of the four retrofit measures (dependent variables). This correlation will help identify the main stakeholder requirements and how the stakeholder type (i.e. tenant, owner, or operator) affects the ranking of their requirements for each of the four sustainable retrofit measures.

## 4.2 – Research Process

The following steps were taken to develop and meet the research objectives. Several steps in the process were performed concurrently and the process that was followed is illustrated in Figure 1.

1. Literature review: sustainable retrofits in existing buildings (Chapter 2)
2. Literature review: House of Quality (HOQ) (Section 4.3)
3. Develop the HOQ model (Section 4.4)
4. Develop the HOQ survey questionnaires (Sections 4.5)
5. Collect data using a case study example (Chapter 5)
6. Analysis of the data and formulation of the results (Chapter 6)
7. Interpretation of the Data and Conclusions (Chapter 7)



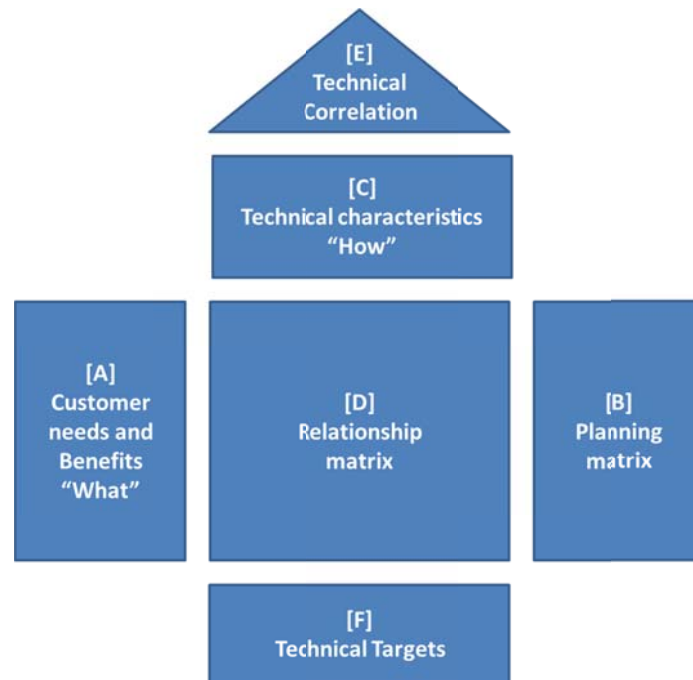
**Figure 1 – Research Process**

### *4.3 – Literature Review, the House of Quality*

#### *4.3.1 – Quality Function Deployment and the House of Quality*

Quality Function Deployment (QFD) is a quality improvement approach that originated under Total Quality Control methodology for new product development in the Japanese shipbuilding and automobile industries (Delgado-Hernandez et al 2007). The principle tool of QFD is the House of Quality (HOQ). The HOQ is an iterative process that utilizes a mathematical analysis using a weighted relationship scale and often a symbolic correlation scale. The calculated results enable the evaluation of functional relationships when prioritizing competing project demands that are subjectively ranked using a numeric scale during analysis. The HOQ contains up to six basic matrices with many steps to follow that are integrated into a system that resembles a house when put together.

The primary matrix sections consist of customer requirements (“what’s”, matrix [A]) in rows, technical solutions (“how’s”, matrix [C]) in columns, a numerically weighted correlation matrix in the center, and the visualized correlation between technical solutions in the triangular matrix on the top that resembles the “roof”. The planning matrix is a competitive analysis of design performance against a benchmark and may be divided into several rows and columns to make a systematic comparison. The matrix on the bottom, or foundation, represents a computed ranking of the technical responses and may also be adaptively divided into several rows and columns to do so. The basic structure of the HOQ can be seen in Figure 2 (Delgado-Hernandez et al. 2007).



**Figure 2 – The House of Quality (adapted from Delgado-Hernandez et al. 2007)**

An explanation of the underlying principles of QFD and step-by-step procedures for the HOQ have been introduced in several publications and can be found in: Ahmed et al 2003, Delgado-Hernandez et al 2007, Dikmen et al 2005, Eldin and Hikle 2003, Mallon and Mulligan 1993, Nieminen and Huovila 200, and Pheng and Yeap 2001. An explanation of the type of information contained in each matrix utilized in this research and step-by-step procedures for processing the HOQ data of this research are presented in this section, Section 4.4, and in Chapter 6, Results.

#### *4.3.2 – House of Quality Applications in the Architecture, Engineering, and Construction Industry*

Literature involving HOQ in the Architecture, Engineering, and Construction (AEC) sector is limited in quantity and construction industry research publications have been steadily

growing. The reasoning for employing QFD in the AEC sector has been the subject of several publications. Fifteen literary investigations were reviewed that examined the applicability and use of HOQ for varying purposes in the industry. These publications support the understanding and implementation of the methodology in conducting additional contributing research. AEC industry research objectives can be broken down into five categories that include:

1. Assessing the awareness of QFD throughout the AEC industry  
(Delgado-Hernandez and Aspinwall 2007; Pheng and Yeap 2001)
  
2. Proposing HOQ methodology as a tool for AEC industry applications  
(Delgado-Hernandez et al. 2006; Dikmen et al. 2005; Huovila and Porkka 2005; Ahmed et al. 2003; Eldin and Hikle 2003; Kamara et al. 2001; Nieminen and Huovila 2000; Alarcon and Mardones 1998; Gargione 1998; Mallon and Mulligan 1993)
  
3. Assessing the suitability of HOQ in the AEC industry using examples and case studies  
(Delgado-Hernandez et al. 2006; Dikmen et al. 2005; Ahmed et al. 2003; Eldin and Hikle 2003; Yang et al. 2003; Gargione 1998; Mallon and Mulligan 1993)
  
4. Proposing improved HOQ models for AEC industry use  
(Dahl 2009; Delgado-Hernandez et al. 2006; Huovila and Porkka 2005; Yang et al. 2003; Kamara and Anumba 2000)
  
5. Studies that used HOQ as the methodology in achieving objectives  
(Dahl 2009; Nieminen and Huovila 2000)

Furthermore, Dikmen et al (2004) classified QFD applications in AEC literature into three categories that included explorations of the methodology before the design stage, during the design stage, and after the design stage with most of the examples occurring in the conceptual design stage.

Pheng and Yeap (2001) found that only 7% of their survey participants were aware of QFD. The researchers concluded that design-build contractors could benefit from the improved cross-functional communication and systematic development of customer requirements that QFD provides, but that it would be difficult to implement due to its complexity and limitations, discussed later in this chapter. Delgado-Hernandez and Aspinwall (2007) reported that although slightly higher, only 18% of a recent survey's respondents were aware of the tool and that its application in the AEC industry may be limited because related literature is scarce. Mallon and Mulligan (1993) promoted awareness by explaining how HOQ is used and its benefits as a management tool. They demonstrated its applicability on a hypothetical computer workroom facility renovation project in order to prioritize desired improvements and found that QFD is suitable as an additional management tool that will produce a better design, contribute to reduced construction costs through fewer design deviations and change orders, and increase the probability of success from the customer's perspective.

The HOQ is a powerful product development tool that can be employed in a wide array of applications. In researching improvements to the design-construction interface, Alarcon and Mardones (1998) utilized the HOQ to identify and prioritize the most effective design quality control tools that could help reduce design discrepancies in the construction phase. Gargione (1999) conducted a study to test the applicability of QFD in construction design and real estate as a tool for adding value from both the buyer and business perspectives to the layout and features

of an apartment unit and obtained encouraging results in improving floor plans. The HOQ proved to be a valuable mechanism for systematically identifying and prioritizing improvements by translating user needs into manageable design information with increased coordination amongst designers.

Kamara et al (2000) proposed the HOQ for enabling integrated information management and communication amongst the many AEC industry stakeholders. Their research established that processes for eliciting and presenting client requirements in the early design stages are inadequate and that the HOQ could allow designers to propose more innovative design solutions by systematically charting client requirements with solution-neutral design parameters. Kamara et al. (2000) concluded that more innovative design solutions could be achieved because the HOQ output includes performance features to focus on, rather than prescriptive technical items to implement. Eldin and Hikle (2003) examined the feasibility of using QFD in developing a conceptual classroom design and found that QFD could be used successfully in AEC design development as it provides procedures that systematically move the design forward while eliminating the need for re-work.

#### *4.3.3 – House of Quality Limitations in Architecture, Engineering, and Construction Industry Applications*

It is evident from research that project development in the AEC industry can benefit from the implementation of QFD in many processes. The HOQ provides a means to coordinate efforts and priorities amongst all stakeholders while maintaining the voice of all customers, internal and external, throughout the life of the project. However, it should be noted that practical limitations

for implementing QFD in AEC industry processes have been identified in research that need to be carefully considered in conducting additional research utilizing HOQ methodology.

One of the biggest challenges in applying QFD methodology in AEC applications is that budget, schedule, and technical constraints have been proven to affect QFD performance. QFD is quality based and the analysis can be carried out as if these items are limitless resources (Dikmen et al 2004). In addition, researchers have reported that the HOQ analysis is a lengthy process that requires a great investment of time and resources (Ahmed et al. 2003; Delgado-Hernandez et al. 2007). Mallon and Mulligan (1993) reported that QFD will not reduce the cost and time required in the project planning stages, but its use will produce a better design that will reduce cost and time in the construction stage.

Researchers also noted that the analysis is primarily subjective and input needs to be obtained from participants with a proper level of training, expertise, intuition, and empowerment. A good HOQ analysis also requires benchmarking data from similar facilities that is often difficult to obtain from competitors, or not readily available in databases. Therefore, existing facilities that are going to be renovated for the same purpose have been said to be an ideal case for HOQ exercises because current performance compared to the original design intent can be used as the benchmark (Mallon and Mulligan 1993).

Further challenges revolve around the size and complexity that matrices can develop into; which often leads to misunderstandings and miscalculations. As a result, most research case studies have been limited to less complex applications in order to demonstrate its potential and increase familiarity (Delgado-Hernandez et al 2007). In addition, researchers concluded that the wide variety of customers, client needs, and technical requirements need to be subjectively reduced to a manageable number, often from matrices of over 100 by 100 to those of less than 20

by 20. In a similar fashion, the HOQ helps in developing better definitions for all levels of customers; however, the list of customers also needs to be limited for manageability and feasibility purposes. More information on limitations and lessons learned can be found from the sources included in Table 1.

**Table 5 – HOQ Limitations in AEC Industry Applications**

| Limitation  | Sources   |
|---|---|
| Budget, schedule, resource allocation, or technical constraints.              | Delgado-Hernandez et al. 2007; Dikmen et al. 2005; Yang et al. 2003   |
| Length and time of process  | Delgado-Hernandez et al. 2007; Dikmen et al. 2005; Ahmed et al. 2003; Eldin and Hikle 2003; Yang et al. 2003  |
| Qualitative and subjective process. Training, experience, intuition required. | Delgado-Hernandez et al. 2007; Dikmen et al. 2005; Ahmed et al. 2003; Yang et al. 2003; Gargione 1998   |
| Size and complexity of matrices   | Delgado-Hernandez et al. 2007; Dikmen et al. 2005; Ahmed et al. 2003; Eldin and Hikle 2003; Yang et al. 2003; Gargione 1998; Mallon and Mulligan 1993 |
| Availability of benchmark data  | Delgado-Hernandez 2007; Dikmen et al. 2005; Huovila 2005  |

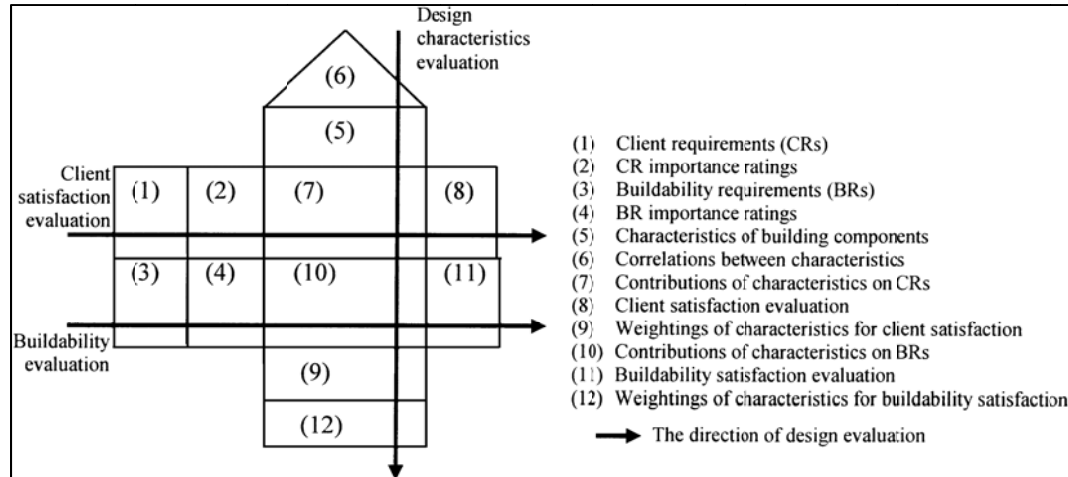
#### *4.3.4 – House of Quality Advancements in Architecture, Engineering, and Construction Industry Applications*

Conventional QFD approaches are tailored to manufacturing industry requirements and the AEC and manufacturing industries are much different in many aspects (Yang et al 2003). Although it has yet to be proven, QFD has the potential to produce benefits in AEC processes that can outweigh the investment of resources. Methods have also been incorporated to overcome several of the limitations. New approaches for AEC sector applications have been developed by researchers that take the limitations into account. Many researches have observed that QFD should be a flexible and adaptable process that can incorporate the specific needs of

each project situation. King (cited in Mallon and Mulligan 1993) recommended a flexible approach because it is not necessary or desirable to work through every HOQ matrix depending on the specific objectives of the exercise. While proposing a template model for capital planning in civil engineering, Ahmed et al (2003) concluded that each HOQ exercise is as unique as each project in itself and HOQ matrices produced most likely cannot be reused as templates for future projects.

Innovations in research implementations for the HOQ in the building and AEC industries include computer software applications, such as ClientPro, that aid in managing complex HOQ matrices and calculations with improved management in processing the many customer requirements (Kamara and Anumba 2000). In addition, EcoProP was developed for similar reasons to provide easier implementation of QFD as a decision support tool in performance based building, and the software also incorporates a database of requirements to incorporate into the HOQ matrices (Huovila and Porkka 2005). Yang et al (2003) explored the potential to develop the HOQ into a quantitative approach by introducing the concept of fuzzy set theory.

In addition, Yang et al (2003) sought out to adapt the HOQ to provide a systematic and structured method to support integrated decision-making in producing buildable designs. The researchers analyzed and evaluated the satisfaction for three dimensions of customers under the overall requirements of the facility. Building on the concept of the three dimensions of customers in buildable design, with the designers as the customer of the client, the contractor as the customer of the designer, and the client the customer of the contractor; Yang et al (2003) introduced the three-dimensional buildability principles into the traditional HOQ framework with a modified HOQ for Buildable Designs (HOQBD, Figure 3).



**Figure 3 – House of Quality for Buildability (HOQBD, Yang et al. 2003)**

Ahmed et al (2003) introduced cost, schedule, and the evaluation of economic project alternatives (rather than traditional customer “what’s” versus technical “how’s”) into their matrices that were used to explore the applicability of QFD in the capital planning process. They concluded that a sensitivity test could be easily conducted to determine how a change in requirements impacts the cost and schedule with a quick visualization from the HOQ. Figure 4 demonstrates how the roof section represents interactions among technical requirements and how changing one element will change the strength of the correlation with that element and the cost of the economic alternative.

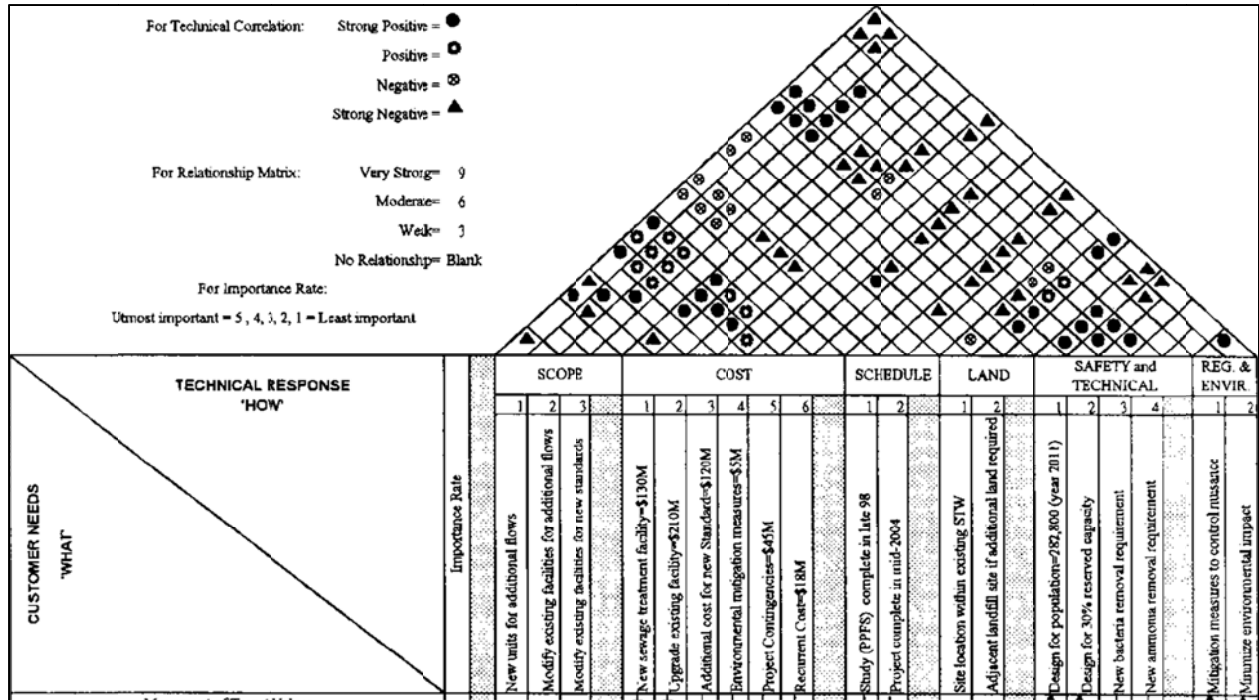


Figure 4 – House of quality (HOQ) Roof (Ahmed et al 2003)

Delgado-Hernandez et al (2006) introduced cost per unit of each technical characteristic into the HOQ matrices; which resulted in an impact to original customer priorities and a more realistic representation of the construction decision making process. Items with lower priority and lower relative cost gained priority over items with higher costs. The technical matrix that incorporated cost in determining priority demonstrated that the hierarchy of customer requirements changed when cost was factored in. For example, an outdoor play area for nursery had the highest relative weight but was ranked fifth in priority beneath items with lower relative weights and much lower costs, such as the finishes for the nursery.

#### *4.3.5 – House of Quality: Energy Performance and Sustainability*

The HOQ process identifies technical measures that have the highest impact on customer requirements and facilitates the prioritization of those technical measures. Therefore, the project team can focus on technical measures with the highest priority and the highest impact on customer satisfaction. Prioritizing energy conservation or sustainable features has not been the primary objective of most research involving QFD. However, many correlations can be drawn from research conclusions that demonstrate that the HOQ is a valuable tool that can be adapted for such purposes.

Dikmen et al (2004) explored the applicability of QFD as a tool to facilitate post construction strategic marketing decisions for a major high rise housing project. The evaluation demonstrated that operations and maintenance provisions were among the highest contributors in satisfying overall customer needs; and that low energy costs, high thermal quality, and efficient central heating were among the customer requirements linked to the highest number of technical measures. A QFD analysis of customer requirements in a new children's nursery demonstrated that temperature control, ventilation, and day lighting were the most important characteristics for this type of learning environment (Delgado-Hernandez et al 2007).

Two research publications have been reviewed that specifically used the HOQ as a design trade-off tool to support the decision making process in energy efficient building designs. Nieminen and Houvila (2000) applied the methodology in prioritizing innovative design concepts for eco-efficient buildings using the framework of a solar heating and cooling program task published by the International Energy Agency (IEA) in 1998. Energy performance and environmental impacts of design concepts, such as energy management and heating systems, were analyzed using energy analysis from similar buildings as a starting point. HOQ analyses

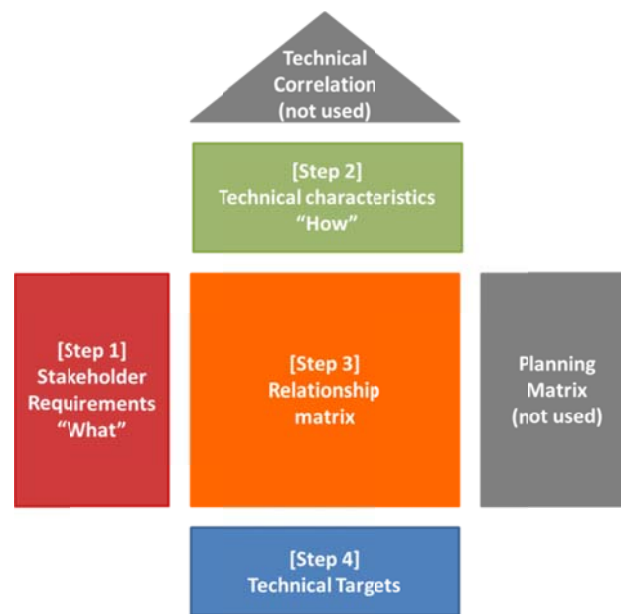
were conducted for a housing project, an office refurbishment, and a nursery school. Low investment and service costs, low environmental impact in use, and good indoor climate were among the listing for most important customer requirements in the nursery school example. It was concluded at the time of the report that energy prices were low enough that the extra costs for implementing energy conservation measures and sustainable design concepts not relating to functionality were difficult to justify. However, it would be interesting to see how current perceptions with higher energy costs and updated policy would change the results this team.

Dahl (2008) investigated post-construction sustainable building performance and introduced a new methodology using the HOQ to process performance data from all stakeholder groups in order to efficiently identify building systems that may not be performing as designed. Research was conducted on two renovation projects for institutional organizations dedicated to long-term sustainability, the United States Department of Defense and Penn State University. The results of this study showed that sustainable buildings do not necessarily perform better than their non-sustainable counterparts. The study also highlighted the tensions that existed between the facility end-users and the project team. In addition, a new HOQ model was proposed that synthesized project requirements resulting from a traditional HOQ analysis with operator interviews, end-user satisfaction, and energy performance ratings to indicate critical building systems for the focus of further investigations (Dahl 2008).

#### *4.4 – Development of the House of Quality for Sustainable Retrofits in Existing Buildings*

The traditional HOQ was formulated for consumer product development in the manufacturing industry (Delgado-Hernandez et al 2007) and several variations have been developed for AEC industry applications as highlighted in the Literature Review of Section 4.3.

The use of some of HOQ matrices depends on the specific objectives of each exercise, and a flexible approach is recommended (Dahl 2009; Ahmed et al. 2003; Mallon and Mulligan 1993). In this research, the Planning and Technical Correlation matrices were not used and an explanation is provided near the end of this chapter in Section 4.4.5 and 4.4.6. The basic HOQ model, labeled in accordance with the matrices and steps taken in this research application, is provided in Figure 5 to allow the reader to follow along with the steps described in this section.



**Figure 5 - Basic House of Quality Template, Labeled Per this Research Application**

#### *4.4.1 – Step 1: Stakeholder Requirements*

The first step in developing a traditional HOQ model for product development is to formulate a full list of customer needs (independent variables) and examine them to determine the critical items that should be entered into the HOQ. In a traditional HOQ, the customers are typically limited to the end-users or clients. In addition, the customer requirements, or “What”, are developed by collecting, grouping, sorting, and eliminating duplicates to account for the features required in the basic product.

The HOQ for analysis of decisions pertaining to sustainable retrofits in existing buildings requires little variation from traditional HOQ models. Thus, in this research, the customers are any stakeholders that may be interested in the outcome of a building retrofit project, rather than just the end-users and clients as in traditional HOQ models. For example, the requirements of the various stakeholders are all included in the customer requirements matrix, such as lower project capital costs and increased the return on investment for the owner; improving occupant comfort, health, and productivity for the tenant; and decreasing outages, achieving lower operating costs, and minimizing the environmental impact for all. Furthermore, an objective of this research is to determine the perceptions of different stakeholders based on the different requirements of all stakeholders relative to the four main technical retrofit measures. For example, this research is interested in examining the tenants' perception of the priorities of other stakeholders compared to theirs; such as the owners, facility managers, or investors. Mechanical system retrofits could be more important to the tenant in order to improve occupant comfort, while the owner may only be interested in mechanical system retrofits to decrease total ownership costs.

The extensive review of literature pertaining to sustainable retrofits in existing buildings revealed the primary motivations of various stakeholders for implementing sustainable retrofits in existing buildings, as introduced in Table 3 of Section 2.5 on page 20. These motivations are used as the stakeholder requirements matrix entries in this research. A total of 30 requirements that were predominantly discussed throughout the reviewed literature were compiled and can be seen in the stakeholder requirements matrix format in Figure 6.

| Potential Stakeholder Requirements: |                                     | a. Importance (1 - 5 scale) |
|-------------------------------------|-------------------------------------|-----------------------------|
| 1                                   | Increase return on investment (ROI) |                             |
| 2                                   | Achieve lower total ownership costs |                             |
| 3                                   | Lower project capital costs         |                             |
| 4                                   | Reduce energy costs                 |                             |
| 5                                   | Increase property value             |                             |
| 6                                   | Achieve higher rental rates         |                             |
| 7                                   | Achieve higher occupancy rates      |                             |
| 8                                   | Avoid costs due to opposition       |                             |
| 9                                   | Improve occupant productivity       |                             |
| 10                                  | Improve corporate reporting results |                             |
| 11                                  | Improve your organization's image   |                             |
| 12                                  | Gain the public's trust             |                             |
| 13                                  | Reduce chance of opposition         |                             |
| 14                                  | Improve aesthetic quality of site   |                             |
| 15                                  | Decrease outages / interruptions    |                             |
| 16                                  | Attract and retain employees        |                             |
| 17                                  | Improve occupant attendance         |                             |
| 18                                  | Improve occupant comfort            |                             |
| 19                                  | Improve occupant health             |                             |
| 20                                  | Increase energy efficiency          |                             |
| 21                                  | Reduce energy consumption           |                             |
| 22                                  | Provide a secure energy supply      |                             |
| 23                                  | Facilitate renewable energy         |                             |
| 24                                  | Minimize environmental impact       |                             |
| 25                                  | Increase carbon neutrality          |                             |
| 26                                  | Reduce costs of carbon offset       |                             |
| 27                                  | Meet regulatory requirements        |                             |
| 28                                  | Comply with policy or legislation   |                             |
| 29                                  | Diversify investment portfolios     |                             |
| 30                                  | Leverage business platforms         |                             |

**Figure 6 – Stakeholder Requirements Matrix**

As discussed in Section 2.5, the stakeholder requirements can all be attributed to one or more of the categories of social, environmental, economic, or technical considerations. Many of the stakeholder requirements included in this table appear to have the same meanings. However, the research team determined that similar stakeholder requirements from each category should not be eliminated. Different requirements may have different meanings for different stakeholders and this study is interested in examining how the stakeholder type and their respective perceptions influence the sustainable retrofit decision. For example, increasing energy efficiency and reducing energy costs appear to mean the same thing. However, environmental regulators may be more concerned with reducing source energy demands to mitigate global environmental impacts while an owner may be more concerned with reducing operating costs regardless of the environmental benefits. Furthermore, the tenant, for example, may feel that to achieve these objectives the building envelope needs to be modified while the owner may feel that upgrades to the mechanical system are the most cost effective solution.

The main function of the stakeholder requirements matrix is for the stakeholders to rate each requirement based on its importance as a project requirement, in addition to defining the objectives and scope of a project. In this research, each stakeholder requirement is a perceived benefit resulting from potential sustainable retrofits. The importance rating for each stakeholder requirement in this research application can be defined as the importance of each requirement in justifying the investment of resources into a sustainable retrofit project in an existing building. This overall importance rating for each stakeholder requirement is independent of the technical importance for the four main technical building systems in meeting the various requirements of the stakeholders; which will be introduced in Section 4.4.3. In this study, importance is intended to be rated by all potential stakeholders, rather than being limited to end-users and clients as in

traditional models, because the requirements being ranked are not just the requirements of the customers.

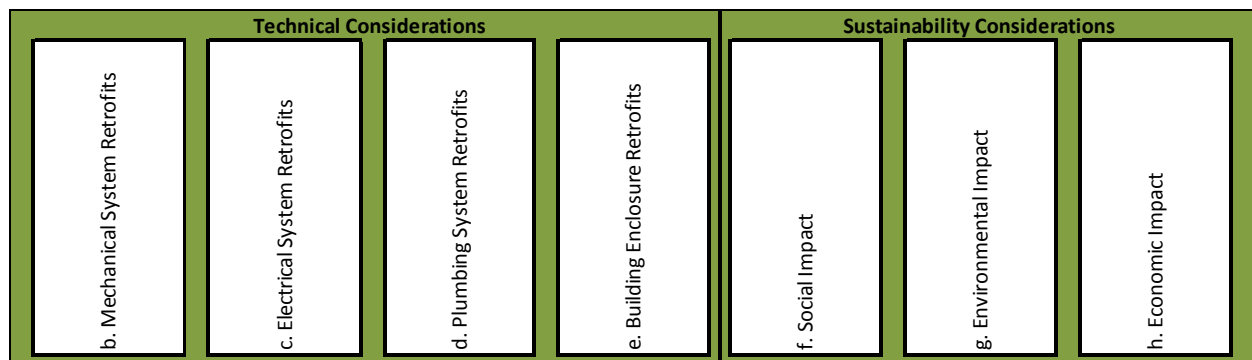
To define the perceived degree of importance of each stakeholder requirement, this study uses a 1 to 5 point scale that assigns a ranking of 5 to extremely important requirements, 4 to very important requirements, 3 to somewhat important requirements, 2 to requirements that are not very important, and a ranking of 1 to requirements that are not important. Since all HOQ research applications reviewed in this study and all literature cited in those applications adopt this scale, it was considered to be an appropriate scale to use (Delgado-Hernandez et al. 2006; Huovila and Porkka 2005; Mallon and Mulligan 1993).

#### *4.4.2 – Step 2: Technical Characteristics Matrix*

The technical characteristics matrix contains the decision alternatives (dependent variables) that are being evaluated in relation to their impact on each stakeholder requirement (independent variables). For this research the sustainable retrofit decision was divided into four main categories of technical retrofits for the building. Building retrofits are interventions, upgrades, modifications, adjustments, or replacement of components within the building. Mechanical system components include items such as the heating ventilation and air conditioning (HVAC) system, HVAC controls, large mechanical system motors and drivers, the building's thermal distribution system, or the HVAC water heating and cooling systems. Electrical system components include items such as lighting fixtures, lighting controls, electrical meters, or electrical circuiting and controls. Plumbing system components include items such as the domestic hot and cold water systems, plumbing fixtures for water and wastewater conveyance, or water conservation and recycling measures. Finally, building envelope, or exterior skin,

components include items such as windows, doors, insulation, roof, daylighting features, or runoff control measures (Prowler 2012).

These four main technical decision alternatives are being investigated in order to meet the research objective of understanding how the requirements of the different building stakeholders affect the sustainable retrofit decision. In addition to technical measures it will be beneficial to assess stakeholder perceptions pertaining to the impact of each stakeholder requirement for sustainable retrofits on social, environmental, and economic considerations as discussed in the literature review section (Chapter 2). This analysis will help identify how each requirement is perceived by the stakeholders to have an impact on social, environmental, and economic considerations. Therefore, these considerations are also included in the technical characteristics matrix of this model. The completed technical characteristics matrix is shown in Figure 7.



**Figure 7 – Technical Characteristics Matrix**

#### 4.4.3 – Step 3: Relationship Matrix

The relationship matrix is the main “room” in the HOQ and shows the extent to which individual measures (mechanical, electrical, plumbing, and external skin; social, environmental, and economic) supports the fulfillment of each stakeholder requirement. Five possible degrees of strength were used in this study to quantify the strength of the relationship between each

stakeholder requirement and each technical measure: 9 (extremely strong), 5 (very strong), 3 (fairly strong), 1 (weak), and 0 (no relationship). For example, a designer may perceive that plumbing system retrofits have a weak ability for decreasing outages and interruptions in the building while the tenant may perceive that such retrofits have an extremely strong ability for decreasing outages and interruptions in the building based on their daily experiences in the building. These five degrees for rating the strength of relationship were defined in several research applications reviewed in Section 4.3, most notably the software based decision support tool application, “QFD ProP”, developed by Huovila and Porkka (2005).

Once the relationship matrix is populated with degree of relationship data as determined by the HOQ team, introduced in Section 5.3.1 of the next chapter, the Technical Importance for each decision alternative (mechanical, electrical, plumbing, and external skin; social, environmental, and economic) is calculated for each relationship cell using Equation 1. It can be seen in Equation 1 that the overall importance introduced in Section 4.4.1 is built into the individual technical importance of each decision alternative in meeting each stakeholder requirement. Therefore, a highly important stakeholder requirement such as improving the aesthetic quality of the site may not receive a high technical importance rating for mechanical system retrofits, for example, because mechanical system retrofits will not enhance the building’s appearance in most situations.

#### **Equation 1 - Individual Technical Importance**

$$\textit{Individual Technical Importance (i, j) = Importance (i) x Relationship (i, j)}$$

EQ. (1)

The relationship matrix is shown in Figure 8 along with the stakeholder requirements matrix and the technical characteristics matrix. An example calculation for the individual technical importance of mechanical system retrofits in fulfilling the stakeholder requirement of improving occupant productivity is also illustrated in Figure 9.

| Potential Stakeholder Requirements: |                                     | Technical Considerations (0-1-3-5-9 scale) |                  |  |                  |  |                  |  |                  |   |                  | Sustainability Considerations (0-1-3-5-9 scale)      |                  |  |                  |  |  |
|-------------------------------------|-------------------------------------|--|------------------|--|------------------|--|------------------|--|------------------|---|------------------|--|------------------|--|------------------|--|--|
|                                     |                                     | a. Importance (1,2,3,4,5 scale)            |                  | b. Mechanical System Retrofits<br>b. Technical Importance (Mech) |                  | c. Electrical System Retrofits<br>c. Technical Importance (Elec) |                  | d. Plumbing System Retrofits<br>d. Technical Importance (Plumbing) |                  | e. Building Enclosure Retrofits<br>e. Technical Importance (Envelope) |                  | f. Social Impact<br>f. Technical Importance (Social) |                  | g. Environmental Impact<br>g. Technical Importance (Env) |                  | h. Economic Impact<br>h. Technical Importance (Economic) |  |
| 1                                   | Increase return on investment (ROI) |  |                  |  |                  |  |                  |  |                  |   |                  |  |                  |  |                  |  |  |
| 2                                   | Achieve lower total ownership costs |  |                  |  |                  |  |                  |  |                  |   |                  |  |                  |  |                  |  |  |
| 3                                   | Lower project capital costs         |  |                  |  |                  |  |                  |  |                  |   |                  |  |                  |  |                  |  |  |
| 4                                   | Reduce energy costs                 |  |                  |  |                  |  |                  |  |                  |   |                  |  |                  |  |                  |  |  |
| 5                                   | Increase property value             |  |                  |  |                  |  |                  |  |                  |   |                  |  |                  |  |                  |  |  |
| 6                                   | Achieve higher rental rates         |  |                  |  |                  |  |                  |  |                  |   |                  |  |                  |  |                  |  |  |
| 7                                   | Achieve higher occupancy rates      |  |                  |  |                  |  |                  |  |                  |   |                  |  |                  |  |                  |  |  |
| 8                                   | Reduce costs due to opposition      |  |                  |  |                  |  |                  |  |                  |   |                  |  |                  |  |                  |  |  |
| 9                                   | Improve occupant productivity       | X <sub>9</sub>                             | Y <sub>9,b</sub> | Z <sub>9,b</sub>   | Y <sub>9,c</sub> | Z <sub>9,c</sub>   | Y <sub>9,d</sub> | Z <sub>9,d</sub>   | Y <sub>9,e</sub> | Z <sub>9,e</sub>  | Y <sub>9,f</sub> | Z <sub>9,f</sub>                                     | Y <sub>9,g</sub> | Z <sub>9,g</sub>   | Y <sub>9,h</sub> | Z <sub>9,h</sub>   |  |
| 10                                  | Improve corporate reputation        |  |                  |  |                  |  |                  |  |                  |   |                  |  |                  |  |                  |  |  |
| 11                                  | Improve your organization's image   |  |                  |  |                  |  |                  |  |                  |   |                  |  |                  |  |                  |  |  |
| 12                                  | Gain the public's trust             |  |                  |  |                  |  |                  |  |                  |   |                  |  |                  |  |                  |  |  |
| 13                                  | Reduce chance of opposition         |  |                  |  |                  |  |                  |  |                  |   |                  |  |                  |  |                  |  |  |
| 14                                  | Improve aesthetic quality of site   |  |                  |  |                  |  |                  |  |                  |   |                  |  |                  |  |                  |  |  |
| 15                                  | Decrease outages / interruptions    |  |                  |  |                  |  |                  |  |                  |   |                  |  |                  |  |                  |  |  |
| 16                                  | Attract and retain employees        |  |                  |  |                  |  |                  |  |                  |   |                  |  |                  |  |                  |  |  |
| 17                                  | Improve occupant attendance         |  |                  |  |                  |  |                  |  |                  |   |                  |  |                  |  |                  |  |  |
| 18                                  | Improve occupant comfort            |  |                  |  |                  |  |                  |  |                  |   |                  |  |                  |  |                  |  |  |
| 19                                  | Improve occupant health             |  |                  |  |                  |  |                  |  |                  |   |                  |  |                  |  |                  |  |  |
| 20                                  | Increase energy efficiency          |  |                  |  |                  |  |                  |  |                  |   |                  |  |                  |  |                  |  |  |
| 21                                  | Reduce energy consumption           |  |                  |  |                  |  |                  |  |                  |   |                  |  |                  |  |                  |  |  |
| 22                                  | Provide a secure energy supply      |  |                  |  |                  |  |                  |  |                  |   |                  |  |                  |  |                  |  |  |
| 23                                  | Facilitate renewable energy         |  |                  |  |                  |  |                  |  |                  |   |                  |  |                  |  |                  |  |  |
| 24                                  | Minimize environmental impact       |  |                  |  |                  |  |                  |  |                  |   |                  |  |                  |  |                  |  |  |
| 25                                  | Increase carbon neutrality          |  |                  |  |                  |  |                  |  |                  |   |                  |  |                  |  |                  |  |  |
| 26                                  | Reduce costs of carbon offset       |  |                  |  |                  |  |                  |  |                  |   |                  |  |                  |  |                  |  |  |
| 27                                  | Meet regulatory requirements        |  |                  |  |                  |  |                  |  |                  |   |                  |  |                  |  |                  |  |  |
| 28                                  | Comply with policy or legislation   |  |                  |  |                  |  |                  |  |                  |   |                  |  |                  |  |                  |  |  |
| 29                                  | Diversify investment portfolios     |  |                  |  |                  |  |                  |  |                  |   |                  |  |                  |  |                  |  |  |
| 30                                  | Leverage business platforms         |  |                  |  |                  |  |                  |  |                  |   |                  |  |                  |  |                  |  |  |

Figure 8 – Stakeholder Requirements, Technical Characteristics, and Relationship Matrices

|    |                                     |       |           |           |           |
|----|-------------------------------------|-------|-----------|-----------|-----------|
| 8  | Avoid costs due to opposition       |       |           |           |           |
| 9  | Improve occupant productivity       | $X_9$ | $Y_{9,b}$ | $Z_{9,b}$ | $Y_{9,c}$ |
| 10 | Improve corporate reporting results |       |           |           |           |

*Individual Technical Importance  $(9, b) = Z_{(9, b)} = X_9 \times Y_{(9, b)}$*

**Figure 9 – Example Calculation: Individual Technical Importance (EQ. 1)**

#### 4.4.4 – Step 4: Technical Targets Matrix

The technical targets matrix is the final step of the HOQ model developed for this research and contains the outcomes of the analysis. A single score for each category of sustainable retrofit measure and consideration in the technical characteristics (“How”) matrix is first calculated using Equation 2, which is simply a sum of the technical importance column for each sustainable retrofit measure (mechanical, electrical, plumbing, envelope) or consideration (social, environmental, economical).

#### Equation 2 - Final Technical Importance

$$\text{Technical Importance } (j) = \sum \text{Individual Technical Importance } (i, j) \quad \text{EQ. (2)}$$

The technical importance is then converted into a relative weight for each category using Equation 3. The relative weight is the single score that represents the prioritization for the overall importance on a scale of 1 to 5. The sustainable retrofit consideration that is assigned a relative weight of 5 is the most important consideration for the focus of design efforts and the consideration with the lowest relative weight is the least important area of focus. The relative weight scale of 1 – 5, with 5 being most important, was used in accordance with the importance scale described in Section 4.4.1. The technical targets matrix can be found in the bottom section of the HOQ. The HOQ for Sustainable Retrofits in Existing Buildings is provided in Figure 10

and an example calculation for technical importance and relative weight can be seen in Figure 11.

**Equation 3 - Relative Weight**

$$\text{Relative Weight (j)} = \frac{\text{Technical Importance (j)} \times 5}{\text{Maximum Technical Importance}}$$

EQ. (3)

| Potential Stakeholder Requirements:     |                                     | a. Importance (1,2,3,4,5 scale) | Technical Considerations (0-1-3-5-9 scale) |                                |                                    |                                    |                                  |                               | Sustainability Considerations (0-1-3-5-9 scale) |                  |                  |                  |                         |                  |                    |                  |
|---|-------------------------------------|---------------------------------|--|--------------------------------|------------------------------------|------------------------------------|----------------------------------|-------------------------------|---|------------------|------------------|------------------|-------------------------|------------------|--------------------|------------------|
|   |                                     |                                 | b. Mechanical System Retrofits             |                                | c. Electrical System Retrofits     |                                    | d. Plumbing System Retrofits     |                               | e. Building Enclosure Retrofits                 |                  | f. Social Impact |                  | g. Environmental Impact |                  | h. Economic Impact |                  |
|   |                                     |                                 | b. Technical Importance (Mech)             | c. Technical Importance (Elec) | d. Technical Importance (Plumbing) | e. Technical Importance (Envelope) | f. Technical Importance (Social) | g. Technical Importance (Env) | h. Technical Importance (Economic)              |                  |                  |                  |                         |                  |                    |                  |
| 1                                       | Increase return on investment (ROI) |                                 | Z <sub>1,b</sub>                           |                                |                                    |                                    |                                  |                               |   |                  |                  |                  |                         |                  |                    |                  |
| 2                                       | Achieve lower total ownership costs |                                 | Z <sub>2,b</sub>                           |                                |                                    |                                    |                                  |                               |   |                  |                  |                  |                         |                  |                    |                  |
| 3                                       | Lower project capital costs         |                                 | Z <sub>3,b</sub>                           |                                |                                    |                                    |                                  |                               |   |                  |                  |                  |                         |                  |                    |                  |
| 4                                       | Reduce energy costs                 |                                 | Z <sub>4,b</sub>                           |                                |                                    |                                    |                                  |                               |   |                  |                  |                  |                         |                  |                    |                  |
| 5                                       | Increase property value             |                                 | Z <sub>5,b</sub>                           |                                |                                    |                                    |                                  |                               |   |                  |                  |                  |                         |                  |                    |                  |
| 6                                       | Achieve higher rental rates         |                                 | Z <sub>6,b</sub>                           |                                |                                    |                                    |                                  |                               |   |                  |                  |                  |                         |                  |                    |                  |
| 7                                       | Achieve higher occupancy rates      |                                 | Z <sub>7,b</sub>                           |                                |                                    |                                    |                                  |                               |   |                  |                  |                  |                         |                  |                    |                  |
| 8                                       | Avoid costs due to opposition       |                                 | Z <sub>8,b</sub>                           |                                |                                    |                                    |                                  |                               |   |                  |                  |                  |                         |                  |                    |                  |
| 9                                       | Improve occupant productivity       | X <sub>9</sub>                  | Y <sub>9,b</sub>                           | Z <sub>9,b</sub>               | Y <sub>9,c</sub>                   | Z <sub>9,c</sub>                   | Y <sub>9,d</sub>                 | Z <sub>9,d</sub>              | Y <sub>9,e</sub>                                | Z <sub>9,e</sub> | Y <sub>9,f</sub> | Z <sub>9,f</sub> | Y <sub>9,g</sub>        | Z <sub>9,g</sub> | Y <sub>9,h</sub>   | Z <sub>9,h</sub> |
| 10                                      | Improve corporate reporting results |                                 | Z <sub>10,b</sub>                          |                                |                                    |                                    |                                  |                               |   |                  |                  |                  |                         |                  |                    |                  |
| 11                                      | Improve your organization's image   |                                 | Z <sub>11,b</sub>                          |                                |                                    |                                    |                                  |                               |   |                  |                  |                  |                         |                  |                    |                  |
| 12                                      | Gain the public's trust             |                                 | Z <sub>12,b</sub>                          |                                |                                    |                                    |                                  |                               |   |                  |                  |                  |                         |                  |                    |                  |
| 13                                      | Reduce chance of opposition         |                                 | Z <sub>13,b</sub>                          |                                |                                    |                                    |                                  |                               |   |                  |                  |                  |                         |                  |                    |                  |
| 14                                      | Improve aesthetic quality of site   |                                 | Z <sub>14,b</sub>                          |                                |                                    |                                    |                                  |                               |   |                  |                  |                  |                         |                  |                    |                  |
| 15                                      | Decrease outages / interruptions    |                                 | Z <sub>15,b</sub>                          |                                |                                    |                                    |                                  |                               |   |                  |                  |                  |                         |                  |                    |                  |
| 16                                      | Attract and retain employees        |                                 | Z <sub>16,b</sub>                          |                                |                                    |                                    |                                  |                               |   |                  |                  |                  |                         |                  |                    |                  |
| 17                                      | Improve occupant attendance         |                                 | Z <sub>17,b</sub>                          |                                |                                    |                                    |                                  |                               |   |                  |                  |                  |                         |                  |                    |                  |
| 18                                      | Improve occupant comfort            |                                 | Z <sub>18,b</sub>                          |                                |                                    |                                    |                                  |                               |   |                  |                  |                  |                         |                  |                    |                  |
| 19                                      | Improve occupant health             |                                 | Z <sub>19,b</sub>                          |                                |                                    |                                    |                                  |                               |   |                  |                  |                  |                         |                  |                    |                  |
| 20                                      | Increase energy efficiency          |                                 | Z <sub>20,b</sub>                          |                                |                                    |                                    |                                  |                               |   |                  |                  |                  |                         |                  |                    |                  |
| 21                                      | Reduce energy consumption           |                                 | Z <sub>21,b</sub>                          |                                |                                    |                                    |                                  |                               |   |                  |                  |                  |                         |                  |                    |                  |
| 22                                      | Provide a secure energy supply      |                                 | Z <sub>22,b</sub>                          |                                |                                    |                                    |                                  |                               |   |                  |                  |                  |                         |                  |                    |                  |
| 23                                      | Facilitate renewable energy         |                                 | Z <sub>23,b</sub>                          |                                |                                    |                                    |                                  |                               |   |                  |                  |                  |                         |                  |                    |                  |
| 24                                      | Minimize environmental impact       |                                 | Z <sub>24,b</sub>                          |                                |                                    |                                    |                                  |                               |   |                  |                  |                  |                         |                  |                    |                  |
| 25                                      | Increase carbon neutrality          |                                 | Z <sub>25,b</sub>                          |                                |                                    |                                    |                                  |                               |   |                  |                  |                  |                         |                  |                    |                  |
| 26                                      | Reduce costs of carbon offset       |                                 | Z <sub>26,b</sub>                          |                                |                                    |                                    |                                  |                               |   |                  |                  |                  |                         |                  |                    |                  |
| 27                                      | Meet regulatory requirements        |                                 | Z <sub>27,b</sub>                          |                                |                                    |                                    |                                  |                               |   |                  |                  |                  |                         |                  |                    |                  |
| 28                                      | Comply with policy or legislation   |                                 | Z <sub>28,b</sub>                          |                                |                                    |                                    |                                  |                               |   |                  |                  |                  |                         |                  |                    |                  |
| 29                                      | Diversify investment portfolios     |                                 | Z <sub>29,b</sub>                          |                                |                                    |                                    |                                  |                               |   |                  |                  |                  |                         |                  |                    |                  |
| 30                                      | Leverage business platforms         |                                 | Z <sub>30,b</sub>                          |                                |                                    |                                    |                                  |                               |   |                  |                  |                  |                         |                  |                    |                  |
| Technical Importance                    |                                     |                                 | T <sub>b</sub>                             |                                |                                    |                                    |                                  |                               |   |                  |                  |                  |                         |                  |                    |                  |
| Relative Weight (1-5, 5 most important) |                                     |                                 | RW <sub>b</sub>                            |                                |                                    |                                    |                                  |                               |   |                  |                  |                  |                         |                  |                    |                  |
| Satisfaction (1-5, 5 least satisfied)   |                                     |                                 |  |                                |                                    |                                    |                                  |                               |   |                  |                  |                  |                         |                  |                    |                  |

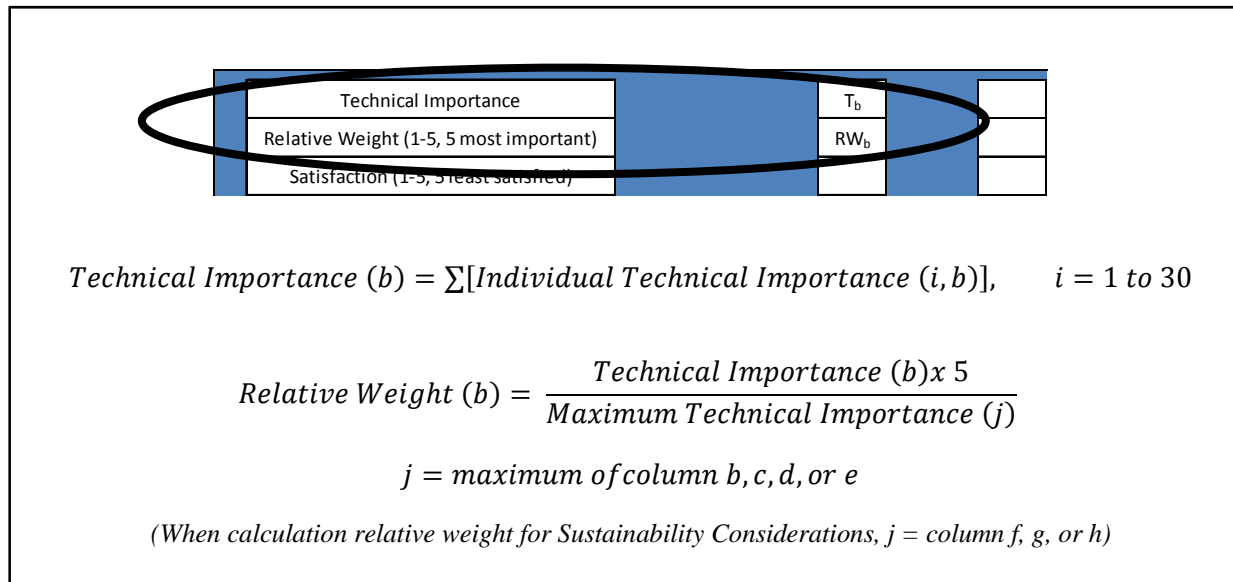
Step 1 (4.4.1) – Stakeholder Requirements Matrix “What”, Survey (4.5.1)

Step 1 (4.4.1) – Stakeholder Requirements Matrix “What”, Survey (4.5.1)

Step 1 (4.4.1) – Stakeholder Requirements Matrix “What”, Survey (4.5.1)

Step 1 (4.4.1) – Stakeholder Requirements Matrix “What”, Survey (4.5.1)

Figure 10 – HOQ for Sustainable Retrofits in Existing Buildings



**Figure 11 – Example Calculations: Technical Importance (EQ. 2) and Relative Weight (EQ. 3)**

The technical targets matrix also contains information that the relative weights of each sustainable retrofit measure can be compared to for further decision analysis. Existing buildings that are going to be retrofitted for the same purpose are ideal cases for benchmarking data, because current performance can be compared to the original design intent in the technical targets matrix rather than through use of the planning matrix (Dahl 2008; Mallon and Mulligan 1993).

In this research model, the existing building condition in the form of occupant satisfaction with each of the four main technical systems of mechanical, electrical, plumbing, and building envelope is being used as a benchmark comparison in the last row of the technical targets matrix. In other words, the results of the HOQ analysis (relative weights) are being verified through a comparison to the current satisfaction with the same building's systems rather than to that of a similar building as would be performed in a planning matrix. For example, the HOQ analysis

may inform the stakeholders that the electrical system is the most important area for the focus of design efforts; however, occupant satisfaction results may state that the occupants are satisfied with the electrical system and more dissatisfied with the mechanical system.

This comparison will be obtained through a building satisfaction survey, which will be introduced in Section 4.5.2. The relative weight for the occupants' level of satisfaction with the building environment, as satisfied by the four main building systems considered in this research, will be calculated using Equation 4. Equation 4 calculations will follow the same procedures as demonstrated in the example calculation in Figure 11; however variables have been replaced with data provided by the occupant satisfaction survey. This relative weight for occupant satisfaction will provide a normalized comparison to the HOQ relative weight of each technical system in meeting stakeholder requirements.

$$\text{Relative Weight (occupant satisfaction}_j) = \frac{\sum \text{Occupant Satisfaction (j)} \times 5}{\text{Maximum Occupant Satisfaction}}$$

EQ. (4)

#### 4.4.5 – Planning Matrix

The planning matrix was not used in this research application. The planning matrix is used to compare the customer requirements of a project with levels of performance or satisfaction for those same requirements on a competitor's project or building, and then to set goals for improvement. The planning matrix requires data from similar competitor facilities that is often difficult to obtain or not readily available in databases (Delgado-Hernandez 2007; Dikmen et al. 2005; Huovila and Porkka 2005).

This research is evaluating what stakeholder requirements can be most influential in the decision to implement sustainable retrofits, relative to stakeholder perceptions of four main technical measures. Therefore, no data exists concerning similar stakeholders' perceptions of what sustainable retrofit requirements are most beneficial for buildings of similar use, age, construction, and condition for a planning matrix comparison. Occupants of a different building can simply be experiencing different issues with their building that might not correlate to the issues experienced by the occupants of the building under evaluation. For example, in a consumer product application, a competitor's refrigerator may have a higher storage capacity than the refrigerator of the company that is performing a HOQ analysis for the design of a new refrigerator that they wish to market. Therefore, that company will want to set a design target size for their new refrigerator to have the same capacity or higher to that of the competing company. However, in this research, data does not exist that measures the level of attainment for stakeholder requirements such as increasing property value, improving occupant productivity, or gaining the public's trust.

#### *4.4.6 – Technical Correlation Matrix (“Roof”)*

As with the planning matrix, the technical correlation matrix (“roof”) was not necessary and would not provide value in this application. The roof is used to evaluate design alternatives by assessing the technical correlation of each selected design alternative with other selected design alternatives. For example, a gas-powered furnace may not require water supplied by the plumbing system; while a heating system that utilized steam produced by a boiler will require a water supply infrastructure and equipment. Therefore, a gas-powered furnace will have no denoted correlation with the plumbing system in the roof; while the heating system that utilizes steam will have a correlation with the plumbing system.

This study is evaluating perceptions concerning potential sustainable retrofits in the broad and general categories of mechanical, electrical, plumbing, and building envelope. Therefore, correlations between the integrated systems cannot be determined until specific technologies are chosen. However, the “roof” may be beneficial in future research once technical focus areas are determined from this research. The technical focus areas determined in this research would become the stakeholder requirements in a second HOQ iteration that investigates the available methods and technologies for each of the four sustainable retrofit categories.

#### *4.5 – House of Quality Survey Development*

##### *4.5.1 – Importance and Relationship Matrix Questionnaire*

The importance rating for the stakeholder requirements matrix and the degree of relationship for the relationship matrix were populated using a survey questionnaire. Collection of quality data is dependent upon asking the right questions. Questions must be carefully selected and properly phrased to extract the most complete and accurate data. For this research, questions were initially drafted and reviewed by the assistant director of the University of Wisconsin-Madison Survey Center.

Questions were reworded to be less formal and more conversational per the survey center’s advice. It is critical to give participants sufficient background information in a statement and then to present simply worded, conversational questions, in the appropriate context. Questions were not phrased and presented to imply any specific answers. This was accomplished by including a short introduction letter to explain the research, providing definitions, and by simply asking the questions in accordance with the structure of the HOQ. Sample questions were provided to get participants started and were then presented in matrix format for ease of use.

After review and guidance was received from the survey center, questions were appropriately sequenced in a way that would seem logical to the participants. In this case, the most straightforward questions were asked first so that participants could obtain an understanding for the objectives and goal of the survey. More complex or abstract questions were saved for the questions at the middle to end of the survey. In addition, questions were rearranged so that similar stakeholder requirements, such as “increase energy efficiency” and “decrease energy costs” were spread-out. This was done so that participants would have a better chance of not associating similar requirements with one another and a better chance of thinking about their meanings individually.

Upon recommendation of the survey center, a unipolar scale was used to translate the importance scale of 1 to 5 and the relationship degree of 0, 1, 3, 5, or 9 into descriptive terms. A unipolar scale prompts a respondent to think of the presence or absence of a quality or attribute. Studies have shown that unipolar scales have the most meaning for participants and have produced better results than bipolar scales that ask participants the degree in which they agree or disagree with a statement. Unipolar scales are more conversational and are more natural for participants (Krebs 2011; Krebs and Hoffmeyer-Zlotnik 2010; Schaeffer and Presser 2003). Additionally, the unipolar terms would decrease the likelihood of all stakeholder requirements receiving an assignment of the highest importance or relationship. While it is possible to assign all of the stakeholder requirements the highest values, if every stakeholder requirement received the same value, then the goal of translating stakeholder requirements into prioritized technical measures would not be achievable.

Eight questions were asked for each of the 30 stakeholder requirements identified in the literature review, for a total of 240 questions. Each of the 8 questions was simply developed to

address the 8 components being evaluated in the columns of the HOQ (Importance Rating of each stakeholder requirement and the degree of relationship for each stakeholder requirement with Mechanical, Electrical, Plumbing, and Envelope System retrofits). Sample questions for one of the potential stakeholder requirements are presented below and the complete survey with definitions can be found in Appendix A.

- **Example questions for the potential stakeholder requirement to reduce energy costs:**

1. A potential requirement for pursuing a sustainable retrofit project in an existing building would be to **reduce energy costs**.

a. How important is this requirement to you in justifying the project, in comparison to all other requirements?

○ Answer choices: Extremely, Very, Somewhat, Not Very, or Not Important

b. How strong is the ability of mechanical system retrofits in meeting the requirement to **reduce energy costs**?

c. How strong is the ability of **electrical system** retrofits in meeting the requirement to **reduce energy costs**?

d. How strong is the ability of **plumbing system retrofits** in meeting the requirement to **reduce energy costs**?

e. How strong is the ability of **building enclosure** retrofits in meeting the requirement to **reduce energy costs**?

- Answer choices for each question: Extremely Strong Ability, Very Strong Ability, Fairly Strong Ability, Weak Ability, No Ability
- f. How strongly are **social factors** impacted by the requirement to **reduce energy costs**?
- g. How strongly are **environmental factors** impacted by the requirement to **reduce energy costs**?
- h. How strongly are **economic considerations** impacted by the requirement to **reduce energy costs**?
- Answer choices for each question: Extremely Strong Impact, Very Strong Impact, Fairly Strong Impact, Weak Impact, No Impact

#### *4.5.2 – Building Occupant Satisfaction Survey*

The relative weights, or final scores, resulting from the HOQ analysis will be compared to a single score that represents the overall satisfaction of stakeholders with the mechanical, electrical, plumbing, and building envelope. This score was obtained through a building evaluation survey. Post-Occupancy Evaluation (POE) surveys have been the subject of several research efforts and it is not the intent of this research to develop, improve upon, or comment on POE surveys. The POE survey used in this research was adapted from Dahl (2008), Bordass and Leaman (2005), and Huizanga et al. (2002).

Questions were worded and presented in accordance with the preceding section. Furthermore, only POE questions that pertained to the main four sustainable technical measures considered in this research were presented. For example, questions relating to the finishes or

furnishings were not presented. All items relating to each technical category were averaged into a single number, 5 being dissatisfied, 4 being not very satisfied, 3 being somewhat satisfied, 2 being satisfied, 1 being very satisfied. Therefore, relative weights and satisfaction ratings with the highest scores should have the highest focus placed on them.

For example, 5 questions were asked concerning satisfaction and reliability of the building's mechanical system components. Responses to these five questions for mechanical systems, all on the same scale, were averaged into a single score. If the average was 5, building occupants were dissatisfied with the mechanical system. If the relative weight for mechanical system retrofits was 5, the HOQ results were validated by the occupants' dissatisfaction and the mechanical system should have a high emphasis placed on it during design investigations. However, if the relative weight for the electrical system was assigned a value of 1 (low design priority) and the occupants' satisfaction with the electrical system was a 5 (dissatisfied), the occupants may be experiencing something that other stakeholders are not aware of and the electrical system should be an area of focus when planning a sustainable retrofit project. This example is illustrated in Figure 12 and the occupant satisfaction survey can be found in Appendix K.

| Electrical System Example: Low Relative Weight, High Dissatisfaction |   |   |  |  |
|--|---|---|--|--|
| $\Sigma$ Technical Importance  |   |   |  |  |
| Relative Weight (1-5, 5 most important)                              | 5 | 1 |  |  |
| Satisfaction (1-5, 5 least satisfied)                                | 5 | 5 |  |  |

| Mechanical System Example: High Relative Weight, High Dissatisfaction |  |  |  |  |
|---|--|--|--|--|
| $\Sigma$ Technical Importance   |  |  |  |  |
| Relative Weight (1-5, 5 most important)                               |  |  |  |  |
| Satisfaction (1-5, 5 least satisfied)                                 |  |  |  |  |

**Figure 12 - Example Occupant Satisfaction Technical Targets Matrix Comparison**

#### 4.6 –Data Analysis Procedures

##### 4.6.1 – Average used for Final HOQ Results

Data obtained through the procedures described in Sections 4.4 and 4.5 will be input into several individual HOQ's. First, a final HOQ analysis will be performed using the data provided by all participants combined, in order to determine what technical systems in the case study building need to be addressed in order to meet the sustainable retrofit requirements of the many different building stakeholders. This will be completed by entering the average data for all participants combined into the importance and technical importance fields of the HOQ.

Typically, in HOQ decision making exercises, only one or two representatives with decision making authority from each stakeholder interest group participate in the analysis (Dahl 2008; Dikmen et al. 2004; Eldin and Hikle 2003; Nieminen and Huovila 2000). However, it is not expected that each group of stakeholders will have the same number of participants because data in this research is being obtained from a survey. For example, 5 owner representatives may participate in the survey while 6 or more tenants may participate. In this research, each of the participating stakeholder groups will be equally accounted for in the average in order to ensure that each group has an equal impact on the final results. For example, only 2 facilities managers

and as many as 10 designers may participate in the HOQ analysis and it is not desired that the perceptions of the designers dominate the perceptions of the facilities managers. Furthermore, if 20 designers participate and only 3 tenants, 4 owners, and 1 facilities manager; the final HOQ decision will mostly represent the perception of designers. Therefore, an average will be taken that equally accounts for each stakeholder interest group to prevent stakeholder groups with more participants from dominating the final HOQ decision; as an objective of this research is to determine what stakeholders are driving the decision according to their requirements, not the size of their group. This average is essentially an average of the individual group averages, and Equation 5 is used to calculate an average that equally accounts for each group (Berenson et al. 2009).

$$\bar{X} = \frac{\sum \left[ \frac{X_i}{n} \right]_k}{N}$$

Where

EQ. (5)

$\bar{X}$  = average that equally accounts for each group (used for Importance and Technical Importance calculations, EQ. (1) and EQ. (3), in the overall HOQ).

$X_i$  = participant (i) response

$n$  = number of participants in each respective stakeholder group

$k$  = number of stakeholder groups

$N$  = number of stakeholder groups represented in the HOQ survey

The second set of HOQ's that will be analyzed and compared will include HOQ results for each individual stakeholder group and a traditional average,  $\sum X_i / n$ , will be used to calculate their results.

#### 4.6.2 – Comparing the HOQ Results from Different Stakeholder Groups

The HOQ uses a multi-attributed approach in its analysis by comparing relative weights of many facets determined by a small group of participants in a working session. Rather than determining if the results are representative of a larger population, this research is interested in determining if there is a difference or not in the perceptions of stakeholder participants in this case study. Therefore, a Pooled-Variance t Test for the Difference Between Two Independent Population Means was used to indicate if the means of two independent stakeholder groups were the same or different.

In this test, the null hypothesis ( $H_0$ ) of no difference in the means of two independent populations ( $\mu_1 = \mu_2$ ) is tested against the alternative that the means are not the same ( $\mu_1 \neq \mu_2$ ). The pooled-variance t-test statistic ( $t_{STAT}$ ) shown in Equation 6 is used to test the null hypothesis. In this research, a level of significance of  $\alpha = 0.05$  and a two-tailed t-test will be used. The null hypothesis will be rejected if the computed  $t_{STAT}$  test statistic is greater than the upper-tail critical value ( $\alpha/2, n_1 + n_2 - 2$  degrees of freedom) from a t-distribution or less than the lower-tail critical value ( $\alpha/2, n_1 + n_2 - 2$  degrees of freedom) from a t-distribution. If the null hypothesis is accepted, this will indicate that the means are the same (the two stakeholder groups agree) with 95 percent confidence. If the null hypothesis is rejected, this will indicate that the means are not the same (disagreement) with 95 percent confidence (Berenson et al. 2009).

Pooled-Variance t Test for the Difference Between Two Means:

$$t_{STAT} = \frac{(\bar{X}_1 - \bar{X}_2) - (\mu_1 - \mu_2)}{\sqrt{S_p^2 \left( \frac{1}{n_1} + \frac{1}{n_2} \right)}} \quad \text{EQ. (6)}$$

where

$$S_p^2 = \frac{(n_1 - 1)S_1^2 + (n_2 - 1)S_2^2}{(n_1 - 1) + (n_2 - 1)}$$

and  $S_p^2$  = pooled variance  
 $\bar{X}_1$  = mean of population 1  
 $S_1^2$  = variance of population 1  
 $n_1$  = size of population 1  
 $\bar{X}_2$  = mean of population 2  
 $S_2^2$  = variance of population 2  
 $n_2$  = size of population 2

The  $t_{\text{STAT}}$  test statistic follows a  $t$  distribution with  $n_1 + n_2 - 2$  degrees of freedom.

#### 4.6.3 – Analysis of Interval Data

The objectives of this research include obtaining the perceptions from different types of stakeholders for what sustainable retrofit requirements are most important, what technical retrofit measures are most important, and how their requirements impact social, environmental, and economic sustainability considerations. These perceptions are being obtained through survey methodologies in which qualitative data was collected. Qualitative variables have values that are placed into categories, such as extremely, very, somewhat, not very, or not important. The assignment of requirements into the qualitative categories was based on the judgment of the survey participants. The qualitative data was translated into a numerical scale to equate the degree of importance into mathematical terms for the HOQ analysis. Furthermore, the numerical data in this research is being measured on an ordinal scale (Berenson et al. 2009).

An ordinal scale classifies data into distinct categories in which ranking is implied. An ordinal scale accounts for the ordering of items within a category (Berenson et al. 2009). The objectives of this research are to determine what the most important stakeholder requirements, technical retrofit solutions, and sustainability impacts are. Therefore, ordinal data analysis and descriptive statistics techniques that analyze ranking will be used to augment the information from the  $t$  test that indicates the difference of magnitudes between two groups that are being compared. For example, owners may believe that lowering project capital costs is extremely important, or a 4.9, while the average tenant perception results in an average value of 4.2 for this requirement. The  $t$  test will indicate if there is a difference in magnitude between the owners' 4.9 and the tenants' 4.2 within the context of variability to assess whether a disagreement exists between those two stakeholders. However, the requirement to lower project capital costs may be ranked within the top five items for each stakeholder. Therefore, the order of ranking will indicate how important the subject requirement is to each stakeholder when compared to all others requirements, and if there is a disagreement concerning the level of ranking for each group.

There are 30-stakeholder requirements being compared in this research and it is necessary to separate the most important stakeholder requirements from those that are not as important. Therefore, an exploratory data analysis and descriptive statistics techniques for ordinal data will be used that include the quartiles for which each retrofit measure belongs to in order to identify the group of most important stakeholder requirements. Quartiles split data sets into four equal parts. The first (1<sup>st</sup>) quartile includes the items that received the lowest 25 percent of the importance values, the second (2<sup>nd</sup>) quartile includes the items that are within 25 percent of the median (middle) value, and the third (3<sup>rd</sup>) quartile includes the remaining 25 percent of the items that received the highest importance ratings. In this research, the third quartile will be used to

indicate those items that were perceived as being most important in the subject area being assessed (Berenson et al. 2009). Microsoft excel programming will be used to calculate the quartile ranges.

#### *4.7 – Summary of Methodology*

The HOQ was selected as a powerful decision making tool with the potential to translate stakeholder requirements into prioritized technical focus areas for sustainable building retrofits. Although research applications in the AEC industry are limited, several studies have been reviewed and the strengths and lessons learned from those applications have been considered. However, these studies did not incorporate the voice of all stakeholders into their analyses. In this research, all participating stakeholders for a case study building will be represented in the assignment of importance and degree of relationship for each potential stakeholder requirement, versus only a small team of designers as done in all other AEC industry applications that were reviewed. Furthermore, the HOQ has been used mainly to make technical decisions relating to the selection of design features. The HOQ has never been used to study the decision making process as attempted in this research application.

## **Chapter 5: Case Study**

### *5.1 – Building Description*

To achieve the objectives of this research, data about building stakeholder requirements, existing building condition, and perceived benefits from the four main technical categories of sustainable retrofits were collected from a case study building located on Naval Station Great Lakes (NAVSTA GL), Illinois. An important barracks building (similar to a dormitory) on this military installation was chosen in collaboration with the installation's Public Works Director, as it represents a significant opportunity on the installation for energy and resource conservation measures. This facility was also selected as the case study building because it represents a variety of stakeholder interactions and the building is in operation 24 hours a day and 7 days a week. The age of the building was another important factor that was taken into consideration in order to study a building that has been in use for many years and in need of technical improvements. Perceptions concerning the benefits of upgrades to the main building systems of mechanical, electrical, plumbing, and external skin in order to extend its lifespan were obtained from this case study building based on the nature of its use, age, and condition.

NAVSTA GL is a dynamic environment where training occurs around the clock. Over 25,000 military and civilian personnel work, train, and live on the base's 10 million square feet of facilities. The training commands and schools proudly deliver thousands of highly skilled, disciplined, and motivated Sailors to the fleet every year. The case study barracks is an 85,400 square foot, 7-story barracks building constructed in 1997. This building is bachelor housing for military staff and transients that have assignments aboard NAVSTA GL. The building has 28 dormitory rooms, a reception area, lounges, and offices on the first floor. Floors two through seven have 45 dormitory rooms and 2 laundry rooms each. There are two types of rooms; suites

with one resident per room and a private bathroom on floors six and seven and dorms with two residents per suite with separate living areas each off of a common kitchenette and bathroom throughout the rest of the building.

In addition, each floor has two mechanical rooms. The building's electrical service distribution, domestic hot water, fire protection, and heating, air conditioning, and ventilation (HVAC) system is spread throughout the building and each floor's mechanical rooms contain one particular piece of equipment. The electrical service and distribution equipment consisting of main switchboards, distribution/branch panels, transformers, and disconnect switches is located on the first level. Domestic hot water steam heat exchangers are located on the third and sixth levels. HVAC air handling units are located on the fourth and fifth floors. Heat exchangers are located on the fifth floor, evaporator sections of the chillers are on the sixth floor, and condensing sections of the chillers are on the rooftop. Various pumps, electrical circuit breakers, and fans are located in all mechanical rooms throughout the building.



**Figure 13 – Case Study Barracks Building, Naval Station Great Lakes, IL**

The stated maximum occupancy of the building is 460, and the typical occupancy rate is 86 percent. Operating hours are from 0700 to 1530, seven days a week, for civilian and military housing staff. During off hours, the staff consists of four personnel from 1530 to 2400 and one person from 2400 to 0700. The staff consists of two military, four civilian operations and maintenance, five civilian office staff, and three rotating managers for a total of fourteen personnel. The building staff reports to central bachelor housing management, located in another building nearby. Table 6 below provides a summary of the building characteristics.

**Table 6 – Case Study Building Characteristics**

|                             |                    |
|-----------------------------|--------------------|
| Building Area (Square Feet) | 85,400             |
| Floors                      | 7                  |
| Year Constructed            | 1998, 14 years old |
| Dormitory Rooms             | 298                |
| Stated Maximum Occupancy    | 460                |
| Typical Occupancy Rate      | 85%                |
| Dedicated Staff Members     | 14                 |
| Staff Hours:                |                    |
| 0700 – 1530                 | 9 personnel        |
| 1530 – 2400                 | 4 personnel        |
| 2400 – 0700                 | 1 person           |

Construction of the case study building was completed in 1997 and since then the building has experienced one major cosmetic renovation in the year 2010 that included updating of interior finishes. The building has not had any major retrofits to its mechanical, electrical, plumbing, and building envelope. Some of the less expensive energy conservation measures have been implemented by means of Energy Savings Performance Contracts (ESPC) and included upgraded lighting fixtures and the installation of low flow faucet aerators, shower heads, and toilets. However, facilities managers indicate that the building is due for major upgrades and repairs based on its age, on an increasing amount of maintenance requests, and that an energy audit and conditions assessment are being evaluated.

## 5.2 – Stakeholders

This facility is of interest to many stakeholder groups, both on and off of the installation, in addition to those discussed in the description above. The installation has a population of over 25,000, 15 large tenant organizations, and is operated by the NAVSTA GL staff consisting of 10 main departmental functions. The “owner” of the case study building would be considered NAVSTA GL and their Immediate Superior in Command (ISIC), Navy Region Midwest (CNRMW), also located onboard NAVSTA Great Lakes. Ultimately, the Navy “owner” of this federally owned facility would be Navy Installations Command located in Washington, D.C.

This facility could be classified as an owner-occupied facility; however, for the purposes of this case study the NAVSTA Great Lakes Bachelor Housing Department and their residents of NAVSTA Great Lakes are considered as the non-rent paying tenants. The financial operating process for this Federal facility is very complex, involves both revolving capital funds and general funds, and is much different than its private counterparts. However, despite organizational differences, the Bachelor Housing Department has a very much vested interest in the outcome of a sustainable retrofit project for this facility in many ways. This department has a genuine interest in the morale and welfare of the military residents, manages a bachelor operations operating budget, and tracks its utilities and maintenance expenses.

Naval Facilities Engineering Command Midwest (NAVFAC MW) is the owners’ service provider that is responsible for the planning, design, construction, sustainment, recapitalization, and disposal of NAVSTA GL’s facilities and supporting infrastructure. NAVFAC MW also produces electricity, water, and steam for NAVSTA GL facilities and is responsible for the utilities and energy management of the installation, including utilities budgeting and revenue to sustain these operations. NAVFAC MW personnel have various facilities roles throughout the

organization, which can be generalized into roles that represent the owner's facility management interests and roles that represent providing services for the benefit of the tenants. Key leaders within NAVFAC MW report concurrently to the owner (NAVSTA GL and CNRMW) and to higher echelons of NAVFAC within the US.

In all case studies, boundary conditions limiting the scope must be established (CMU 2008). For the purposes of this research and due to the complexity of organizational relationships, the availability of data, and the time allotted to conduct the study; NAVSTA GL Bachelor Housing will represent the tenants, base public, and clients. Separate and individual departments within NAVFAC MW will represent other stakeholder interest groups such as the owner, financiers, facilities managers, operations and maintenance staffs, service contractors, utilities providers, government agents, and environmental compliance groups in accordance with the distinct functions that these departments serve.

### *5.3 – Data Collection*

#### *5.3.1 – House of Quality Importance and Relationship Matrix Questionnaire*

The use of the HOQ is a qualitative and subjective process. Those who have researched HOQ applications in the AEC industry have noted that participants must have proper experience, intuition, and decision making authority in order to obtain efficient results in this decision making exercise (Delgado-Hernandez et al. 2007; Dikmen et al. 2005; Ahmed et al. 2003; Yang et al. 2003; Gargione 1998). Allocation of the degree of importance (Section 4.4.1) and relationship (Section 4.4.3) is based entirely on professional judgment (Ahmed et al. 2003). Participants in HOQ research applications have primarily consisted of anywhere between three members of a research team (Dikmen et al. 2004), four members of a design team (Dahl 2008),

and ten experts with different architectural, engineering, and business backgrounds (Eldin and Hikle 2003; Nieminen and Huovila 2000).

The data collection goal of this research was to obtain data from many stakeholders with diverse backgrounds in order to meet the research objective of understanding how the requirements of different stakeholders affect the sustainable retrofit decision. In order to achieve this goal while respecting lessons learned from research applications, data collection began with department directors representing the stakeholder interests described in Section 5.2, Stakeholders. The following is a list of the titles of the HOQ importance and relationship survey participants and the stakeholder classification that they represented:

1. Installation Bachelor Housing Department Head – Tenant
2. Installation Bachelor Housing Building Manager - Tenant
3. Regional Real Property Business Line Director – Owner
4. Regional Utilities and Energy Management Business Line Director - Owner
5. Installation Deputy Public Works Director – Facilities Managers
6. Installation Director of Facilities Maintenance – Facilities Managers
7. Regional Capital Improvements Business Line Team Leader – Designers
8. Installation Facilities Engineering and Acquisition Director – Designers
9. Regional Environmental Business Line Team Leader – Environmental Compliance

The above list of stakeholder representatives are all in positions to officially commit to decisions made in the HOQ analysis. These representatives concurred with the stakeholder classification in which they were assigned and also concurred with who should represent the other stakeholder groups. The stakeholder interest groups that representatives were classified into are fairly straightforward, with the following explanations. The Regional Real Property

Business Line Director was chosen to represent the owner as a senior leader responsible for master planning, real property management, project programming, and project budgeting on behalf of the Navy owners. The Regional Utilities and Energy Management Business Line Director was also chosen to represent the owner as a senior leader responsible for utilities budgeting and reporting compliance with Federal energy reduction directives on the behalf of Navy owners.

Each of these senior level stakeholder representatives was contacted individually either by phone or in person. During these conversations, the intent of this research, potential stakeholder requirements identified in the literature review, and HOQ survey questions were presented to the participants. Interesting points were made by several stakeholders during these conversations concerning their perceptions in relationship to this research. For example, a tenant representative highlighted reasons why achieving higher occupancy and rental rates were not as important to his organization as they might be to a private hotel. The HOQ Survey Questionnaire is available in Appendix A.

Upon completion of the HOQ questionnaire, each representative transmitted their results to the research team in a spreadsheet by email and was also contacted again by phone to convey our gratitude and obtain clarification and feedback concerning their perceptions when necessary. None of these conversations resulted in changes to their original responses.

In addition, permission was obtained to utilize volunteers from each director's staff. The questionnaire was explained and distributed to those staff members by the director, or the staff member was contacted by the research investigator. In addition to the senior leaders listed above, additional responses were obtained from their direct reports for a total of 30 participants

as described in Table 7. The responses and a summary of the data can be found in Appendices B – I.

**Table 7 – Case Study Stakeholders**

| Stakeholder               | Participants | Functions Represented  |
|---------------------------|--------------|--|
| 1. Tenant                 | 6            | tenant organization, occupants, base public, client  |
| 2. Owner                  | 6            | owner, financier, real estate, utilities budgeting   |
| 3. Facility Managers      | 8            | operations and maintenance, construction management, contractors, facilities acquisition   |
| 4. Designers              | 8            | capital improvements, architects, engineers  |
| 5. Environmental Managers | 2            | Environmental Protection Agency concerns, State Historic and Preservation Society concerns, National Environmental Policy Act, government agents, environmental compliance |
| TOTAL                     | 30           |  |

### 5.3.2 – Building Occupant Satisfaction Survey

The occupant satisfaction survey was used as a comparison benchmark for the HOQ Technical Targets matrix. This survey was facilitated using the web-based software, Qualtrics, available through the University of Wisconsin, Madison Qualtrics Survey Hosting Service. Data collection using this survey began by contacting the Installation Bachelor Housing Building Manager. The online survey link was then distributed to all members of the Bachelor Housing Staff by the Building Manager and to 41 occupants for whom Bachelor Housing possessed valid email addresses, for a total of approximately 55 survey candidates. The survey could not be distributed to all building occupants, as the building is primarily occupied by transient personnel for whom email addresses are not readily available. In addition, most residents do not reside in the building long enough to experience all aspects of the building environment during all seasons of weather.

Responses were obtained from 30 of individuals, including a 100 percent response rate for the building's 14 dedicated staff members and 16 responses from individuals who reside in

the building and have longer term assignments on NAVSTA GL. Six staff members participated in both surveys, the HOQ Importance Rating and Relationship Matrix Survey and the Building Occupant Satisfaction Survey. The responses and a summary of the data can be found in Appendix L.

## Chapter 6: Results

HOQ importance rating and degree of relationship data was collected in accordance with the procedures presented in Sections 4.5.1 and 5.3.1 (Methodology and Case Study - Importance and Relationship Matrix Questionnaire). Data regarding the level of occupant satisfaction with the current performance of each of the four main building systems of mechanical, electrical, plumbing, and building envelope was collected in accordance with the procedures presented in Sections 4.5.6 and 5.3.2 (Methodology and Case Study - Building Occupant Satisfaction Survey). Survey responses for each individual that participated in the HOQ Importance and Relationship Matrix Questionnaire are available in Appendices B – I. Survey responses for each individual that participated in the Building Occupant Satisfaction Survey are available in Appendix L.

After the data was received, it was subsequently populated into the HOQ model and calculations were performed using Microsoft Excel in accordance with the procedures that were presented in Section 4.4 (Methodology - Development of the House of Quality for Sustainable Retrofits in Existing Buildings). A final HOQ analysis was performed by using the data provided by all participants combined, in order to determine what technical systems in the case study building need to be addressed in order to meet the sustainable retrofit requirements of the many different building stakeholders. This HOQ analysis will also provide an indication of how the requirements of the different building stakeholders are perceived to have an impact on each of the three sustainability considerations (Social, Environmental, and Economic). The results of this final HOQ analysis will be presented in the following section. In addition, a separate HOQ analysis was performed for each individual stakeholder group that was identified in Section 5.3.1 (tenants, owners, facility managers, designers, and environmental managers) to determine how

different stakeholder groups perceive that the case study building should be retrofitted, when compared to one another and to the overall results.

Further analysis of the HOQ data was then performed to determine what stakeholder requirements were most influential in the decision to implement sustainable retrofits, relative to stakeholder perceptions of the four main technical measures considered in this research. For instance, the HOQ entries were first analyzed to determine what stakeholder requirements were most important to the stakeholders without considering the mechanical, electrical, plumbing, or building envelope systems of the building. Then, the HOQ entries were analyzed to determine what stakeholder requirements were most important to the stakeholders for implementing retrofits in each of the four main building systems. This was done by analyzing the importance rating column for each of the 30-stakeholder requirement and the technical importance of each of the 30-stakeholder requirements within each of 4-technical characteristics columns of the HOQ (b. Mechanical System, c. Electrical System, d. Plumbing System, and e. Building Envelope retrofits). This analysis was performed for the combined data of all participants involved.

Lastly, as illustrated throughout examples and in the literature reviewed in this study, it has been observed that there is conflict among opposing stakeholder groups and that this conflict acts as a main barrier for the existing building community in implementing sustainable retrofits and achieving their sustainable building objectives (Yudelson 2010; Scofield 2009; Beheiry et al. 2006; Bosch and Pearce 2003). In order to study this conflict and to provide a further determination of how the stakeholder type affects the ranking of their requirements, pairs of opposing stakeholder groups were analyzed. For example, HOQ results were used to compare the perception of the tenant to those of the owner, or perceptions of the designer to those of the

facilities managers. Opposing stakeholder groups were chosen based on literary examples and indications of conflict that were detected during the HOQ analysis.

### *6.1 – Case Study, Final HOQ Results:*

Thirty stakeholders as described in Section 5.3.1 participated in the HOQ Importance and Relationship Matrix Survey and the stakeholders were categorized into the following groups: 1. tenant, 2. owner, 3. facility managers, 4. designers, and 5. environmental managers. The responses for each individual and a summary of the average responses are available in Appendices B – I. The average response for each question, calculated using procedures that equally account for each stakeholder group using EQ. (5), as described in Section 4.6.1, was entered into the importance rating and technical importance fields in the HOQ model.

Thirty building occupant representatives, including the six tenant representatives that participated in the HOQ questionnaire, participated in the Occupant Satisfaction Survey. Each of the 19 questions was categorized to represent occupant satisfaction with either the mechanical, electrical, plumbing, or the building envelope system. There were 5 questions for each of the mechanical, electrical, and building envelope systems and 4 questions for the plumbing system. The scale that represents occupant satisfaction is as follows: 5 – dissatisfied, 4 – not very satisfied, 3 – somewhat satisfied, 2 – satisfied, 1 – very satisfied. The relative weight for occupant satisfaction with each of the four main building systems was calculated in accordance with EQ. (3) procedures and entered into the technical targets matrix. The building system with the highest relative weight represents the system that the occupants are least satisfied with. The responses for each individual and a summary of the data are available in Appendix L.

The HOQ is displayed and discussed in two sections, one HOQ that includes the technical characteristics matrix for the main sustainable retrofit measures of mechanical, electrical, plumbing, and building envelope retrofits (Section 6.1); and one HOQ that includes the technical characteristics matrix for social, environmental, and economic sustainability considerations (Section 6.5). The final HOQ results for the first display, technical retrofit measures, are shown in Figure 14 on page 77. Sample calculations for the importance of the stakeholder requirement of meeting regulatory requirements, the technical importance of electrical system retrofits in meeting that requirement, and the relative weight of the electrical system in fulfilling all stakeholder requirements are provided on pages J-7 to J-11 starting with Figure 38 in Appendix J. A sample calculation for the relative weight of occupant satisfaction with the plumbing system is on page L-3 in Appendix L.

| House of Quality: Average Results, All Stakeholders Combined |                                     |  |        |  |       |  |       |  |       |   |  |
|--|-------------------------------------|--|--------|--|-------|--|-------|--|-------|---|--|
| Potential Stakeholder Requirements:                          |                                     | Technical Considerations (0-1-3-5-9 scale) |        |  |       |  |       |  |       |   |  |
|  |                                     | a. Importance (1 - 5 scale)                |        | b. Mechanical System Retrofits<br>b. Technical Importance (Mech) |       | c. Electrical System Retrofits<br>c. Technical Importance (Elec) |       | d. Plumbing System Retrofits<br>d. Technical Importance (Plumbing) |       | e. Building Enclosure Retrofits<br>e. Technical Importance (Envelope) |  |
| 1  | Reduce energy costs                 | 4.9  | 6.2    | 30.5   | 4.5   | 22.5   | 6.0   | 10.4   | 4.8   | 24.1  |  |
| 2  | Increase return on investment       | 4.6  | 5.4    | 25.4   | 4.2   | 20.0   | 5.3   | 10.2   | 3.8   | 17.8  |  |
| 3  | Minimize environmental impact       | 3.7  | 4.5    | 17.2   | 3.4   | 13.2   | 4.4   | 13.6   | 3.1   | 11.8  |  |
| 4  | Improve your organization's image   | 3.1  | 1.5    | 4.8  | 3.0   | 9.6  | 1.5   | 5.0  | 4.4   | 14.7  |  |
| 5  | Improve occupant comfort            | 3.5  | 7.0    | 24.9   | 3.0   | 10.6   | 6.9   | 5.6  | 4.9   | 16.9  |  |
| 6  | Increase energy efficiency          | 4.5  | 6.8    | 30.3   | 5.4   | 24.4   | 6.7   | 10.2   | 5.4   | 24.4  |  |
| 7  | Increase carbon neutrality          | 2.3  | 4.4    | 11.2   | 4.4   | 11.0   | 4.4   | 2.0  | 3.5   | 9.1   |  |
| 8  | Achieve lower total ownership costs | 4.6  | 5.9    | 27.8   | 4.6   | 21.2   | 5.9   | 14.8   | 4.7   | 22.7  |  |
| 9  | Meet regulatory requirements        | 4.2  | 3.6    | 15.7   | 2.9   | 12.2   | 3.6   | 17.3   | 3.0   | 13.3  |  |
| 10   | Comply with policy or legislation   | 4.6  | 5.0    | 23.2   | 5.1   | 23.3   | 5.0   | 18.7   | 3.7   | 17.2  |  |
| 11   | Improve aesthetic quality of site   | 2.3  | 0.5    | 1.0  | 1.5   | 3.0  | 0.5   | 1.8  | 6.1   | 14.9  |  |
| 12   | Improve occupant productivity       | 3.7  | 3.9    | 14.6   | 2.8   | 10.2   | 3.9   | 6.3  | 2.7   | 9.7   |  |
| 13   | Reduce chance of opposition         | 2.7  | 1.9    | 6.3  | 2.3   | 7.9  | 1.9   | 6.3  | 3.6   | 11.2  |  |
| 14   | Increase property value             | 2.1  | 3.1    | 7.1  | 2.4   | 6.0  | 3.0   | 5.5  | 4.8   | 11.7  |  |
| 15   | Reduce energy consumption           | 4.5  | 7.1    | 31.9   | 5.5   | 25.9   | 6.9   | 10.6   | 4.9   | 22.3  |  |
| 16   | Provide a secure energy supply      | 3.4  | 3.2    | 11.2   | 3.8   | 14.2   | 3.1   | 4.3  | 1.9   | 6.8   |  |
| 17   | Facilitate renewable energy         | 3.1  | 3.5    | 11.2   | 4.1   | 13.4   | 3.5   | 4.6  | 3.2   | 9.7   |  |
| 18   | Lower project capital costs         | 3.4  | 3.8    | 15.5   | 3.0   | 12.4   | 3.7   | 8.7  | 3.2   | 14.0  |  |
| 19   | Reduce costs of carbon offset       | 2.0  | 3.8    | 8.4  | 4.0   | 8.9  | 3.7   | 2.5  | 2.9   | 6.7   |  |
| 20   | Achieve higher rental rates         | 2.2  | 2.4    | 5.9  | 2.1   | 5.5  | 2.4   | 4.9  | 3.7   | 9.3   |  |
| 21   | Achieve higher occupancy rates      | 2.5  | 3.3    | 7.9  | 2.4   | 6.4  | 3.3   | 5.7  | 3.7   | 10.2  |  |
| 22   | Avoid costs due to opposition       | 2.7  | 1.6    | 5.0  | 1.6   | 5.1  | 1.6   | 5.9  | 2.9   | 9.2   |  |
| 23   | Gain the public's trust             | 3.4  | 1.3    | 4.4  | 1.4   | 5.2  | 1.2   | 5.1  | 2.3   | 8.1   |  |
| 24   | Decrease outages / interruptions    | 3.8  | 4.9    | 19.3   | 4.9   | 19.4   | 4.9   | 12.4   | 1.1   | 4.2   |  |
| 25   | Attract and retain employees        | 2.9  | 2.2    | 7.4  | 1.9   | 6.6  | 2.1   | 5.6  | 3.3   | 11.7  |  |
| 26   | Improve occupant attendance         | 2.7  | 3.0    | 10.6   | 1.9   | 6.5  | 2.9   | 6.1  | 2.1   | 7.5   |  |
| 27   | Improve occupant health             | 3.3  | 5.0    | 17.2   | 1.9   | 6.7  | 5.0   | 7.9  | 2.3   | 8.3   |  |
| 28   | Improve corporate reporting results | 3.8  | 3.0    | 12.1   | 3.7   | 15.7   | 3.0   | 13.1   | 3.3   | 13.8  |  |
| 29   | Diversify investment portfolios     | 1.9  | 1.4    | 3.2  | 1.3   | 2.7  | 1.4   | 2.5  | 1.7   | 4.1   |  |
| 30   | Leverage business platforms         | 3.1  | 2.2    | 7.6  | 1.9   | 7.4  | 2.1   | 4.2  | 1.8   | 6.0   |  |
| Σ Technical Importance                                       |                                     |  | 419    |  | 357   |  | 231   |  | 371   |   |  |
| Relative Weight (1-5, 5 most important)                      |                                     |  | 5.00   |  | 4.26  |  | 2.76  |  | 4.43  |   |  |
| Σ Occupant Satisfaction Points                               |                                     |  | 71.667 |  | 55.75 |  | 68.75 |  | 72.00 |   |  |
| Relative Weight (1-5, 5 least satisfied)                     |                                     |  | 4.98   |  | 3.87  |  | 4.77  |  | 5.00  |   |  |

Figure 14 – HOQ for Technical Considerations, Equal Stakeholder Group Representation

The completed technical targets matrix for sustainable retrofit measures is shown once again in Figure 15 below. Calculations for percent of total technical importance and percent of total dissatisfaction were included in the matrix, in addition to the traditional HOQ comparison of relative weights on a scale of 5.0. An example calculation is provided in Figure 16.

|  | b. Mechanical System Retrofits | c. Electrical System Retrofits | d. Plumbing System Retrofits | e. Building Enclosure Retrofits | TOTAL        |
|--|--------------------------------|--------------------------------|------------------------------|---------------------------------|--------------|
| $\Sigma$ Technical Importance            | 419                            | 357                            | 231                          | 371                             | <b>1379</b>  |
| % Total Technical Importance             | 30%                            | 26%                            | 17%                          | 27%                             | <b>100%</b>  |
| Relative Weight (1-5, 5 most important)  | 5.00                           | 4.26                           | 2.76                         | 4.43                            |              |
| $\Sigma$ Occupant Satisfaction Points    | 71.7                           | 55.8                           | 68.8                         | 72.0                            | <b>268.2</b> |
| % Dissatisfaction                        | 27%                            | 21%                            | 26%                          | 27%                             | <b>100%</b>  |
| Relative Weight (1-5, 5 least satisfied) | 4.98                           | 3.87                           | 4.77                         | 5.00                            |              |

**Figure 15 – Technical Targets Matrix, Sustainable Retrofit Measures**

$$\begin{aligned} \Sigma \text{Technical Importance} &= 1379 \\ \% \text{Technical Importance (mechanical)} &= \% \text{Technical Importance (b)} \\ &= \frac{419}{1379} = 30\% \end{aligned}$$

**Figure 16 – Sample Calculation, Percent Technical Importance**

Figure 15, the technical targets matrix, includes the compilation of all data from the full HOQ model for sustainable retrofits in existing buildings. The full HOQ matrix contains a substantial amount of useful information that will be further analyzed later in this chapter. However, this technical targets matrix synthesizes the perceptions of all stakeholders involved regarding what technical systems need to be addressed in order to meet their many sustainable retrofit requirements. Furthermore, a greater understanding of the HOQ results and building characteristics are obtained by including and comparing information concerning occupant satisfaction.

Figure 15 informs the stakeholders that the highest priority for the focus of design efforts should be on the building's mechanical system, with a relative weight of 5.0 and 30 percent of the technical importance. The second highest priority is the building envelope, with a relative weight of 4.4 and 27 percent of the technical importance. The electrical system is a slightly lower priority for meeting the stakeholders' sustainable retrofit requirements, with a relative weight of 4.26 and 26 percent of the technical importance. Lastly, the plumbing system in the case study building may not need as much effort placed on it during design investigations, with the lowest relative weight of 2.76 and only 17 percent of the technical importance.

Additionally, the level of occupant satisfaction with the same respective technical systems provides valuable information that can be used to validate and supplement the HOQ results. The plumbing system needs the least attention during design efforts according to its relative weight in the HOQ. However, the occupant satisfaction results from those that are experiencing the building environment on a daily basis, informs the other stakeholders that there are issues with the plumbing system that need to be addressed. According to occupant satisfaction, the relative weight for the plumbing system is 4.77 and 26 percent of the total

occupant dissatisfaction. These dissatisfaction figures are very high compared to the low relative weight of 2.76 and 17 percent technical importance resulting from the HOQ. Therefore, the building users are experiencing issues with the plumbing system that the HOQ participants aren't necessarily familiar with.

Furthermore, the Occupant Satisfaction Survey afforded participants the opportunity to comment on the building characteristics that they are not satisfied with. Upon review of the 11 comments that were provided concerning plumbing system dissatisfaction, available in Appendix L; the occupants are experiencing problems with the water conservation measures that were recently implemented in the building as described in Section 5.1. Occupants are reporting that the newly installed low flow plumbing fixtures are leaking and breaking. In addition, the occupants are not satisfied with the water pressure in the showers and with the amount of time that it takes for hot water to reach their showers. Due to the fact that the fixtures were recently installed, most of the senior level decision making participants in the HOQ analysis, that do not have familiarity with maintenance requests, most likely have an understanding that plumbing system retrofits have been completed and therefore do not need to be addressed in a future sustainable retrofit project. Therefore, the occupant evaluation survey proved to be an important comparison that supplemented the HOQ analysis with valuable information.

The occupant satisfaction survey also indicated that the occupants were not as concerned with the building's electrical system as were the stakeholders that participated in the development of the HOQ decisions. Occupant relative weight for dissatisfaction was 3.87 and 21 percent of total dissatisfaction compared to a relative weight of 4.26 and 26 percent of the total technical importance. Six occupant comments indicated that lighting was too dim in occupant suites and workspaces. Upgraded energy efficient lighting fixtures have been recently

installed in the building as described in Section 5.1. According to the HOQ results, the HOQ participants feel that there is still slight room for improvement regarding the electrical system in meeting their sustainable retrofit requirements while the occupants are overall satisfied with the level of artificial lighting and daylighting that is being provided.

The occupant satisfaction comparison was also beneficial because it validated the results of the HOQ analysis, proving the HOQ to be a valuable exercise for eliciting the most important technical requirements in response to competing stakeholder requirements for sustainable retrofits. All stakeholders placed a high emphasis on the need to investigate the building's mechanical and building envelope systems. Both systems received high relative weights, percent importance, and percent dissatisfaction of almost 5.0 and 30 percent in all cases. In addition, the occupant satisfaction survey received comments pertaining to dissatisfaction with both the HVAC system and the building envelope.

The Navy has a policy that mandates the thermostat temperature set points to 72 degrees Fahrenheit during the heating season and 78 degrees Fahrenheit during the cooling season as an energy savings measure. The bachelor occupants feel that this policy is appropriate for the workplace but not for their residential quarters, as Navy families in government single family homes do not have to abide by this policy. Furthermore, the occupants report that the thermostats in their living quarters are outdated and give the residents the impression that they can adjust their own temperature when the controls are actually overridden by digital controls in accordance with the temperature set point policy. The tenants also believe that the thermostats are improperly placed, near the kitchen area, which causes the temperature in the private bedroom spaces to be inconsistent with the thermostat temperature reading. In addition, the bedrooms are the only rooms with windows and the occupants report that the windows are

inadequate to stop cold air from infiltrating during the winter and from stopping heat gain during the summer. All of these comments provide valuable information that supplement the HOQ findings and need to be addressed during planning and design efforts.

As demonstrated above, the technical targets matrix is used to identify discrepancies within the building and address the conflict between stakeholder groups. In this case study example, the technical targets matrix validated sustainable retrofit requirements and identified potential misinterpretations of retrofit requirements that could have otherwise been overlooked. The technical targets matrix does not necessarily provide the exact answer to project requirements. However, it provides a very thorough and structured review of critical building issues and requirements that must be addressed in order to integrate the competing requirements of all stakeholders in achieving their many sustainable retrofit objectives.

## *6.2 – Technical Targets Matrix: Stakeholder Comparison*

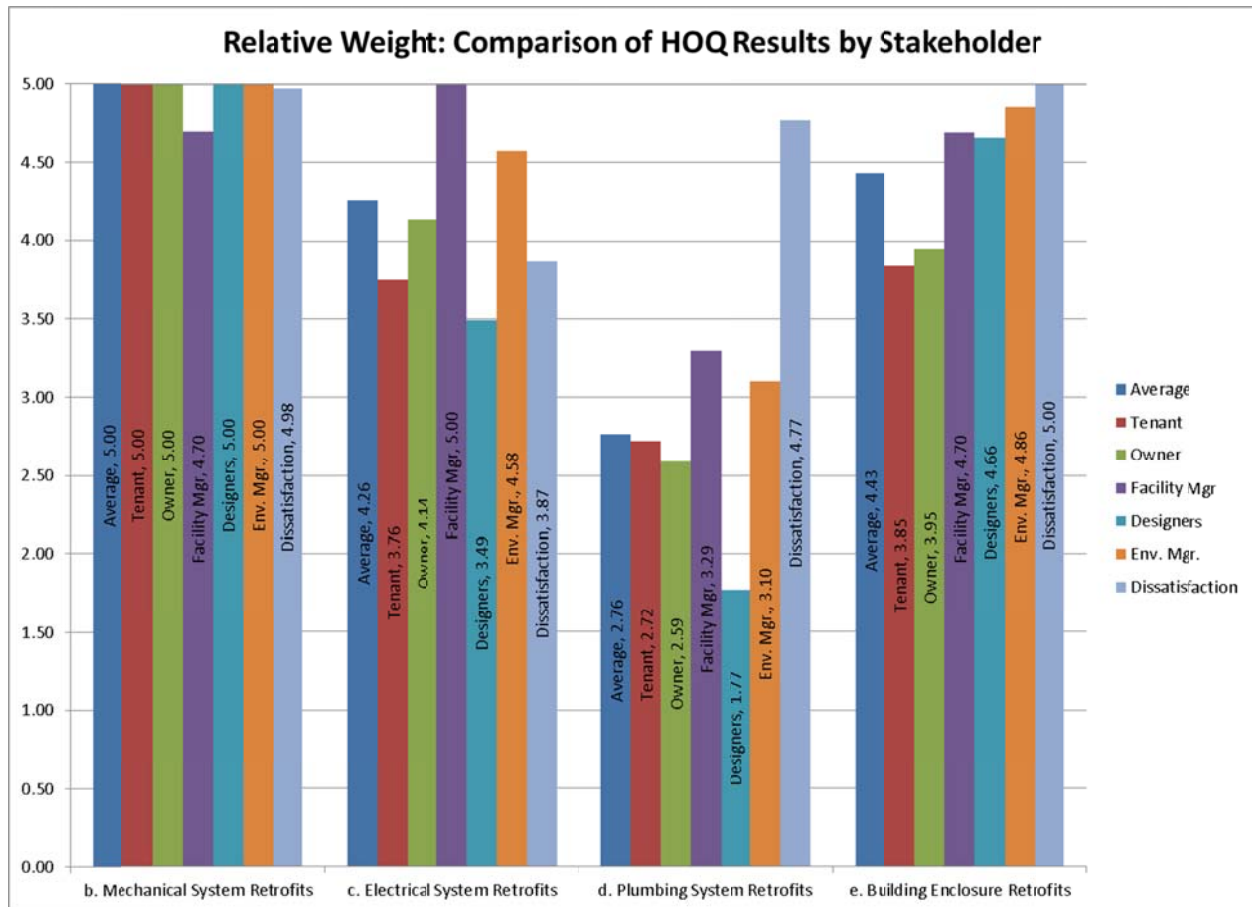
It has been demonstrated that the technical targets matrix is a useful tool in translating many competing stakeholder requirements into technical focus areas for project planning and design. The technical targets matrix contains valuable information concerning the perceptions of the different stakeholders regarding what technical systems are most important in order to address their many sustainable retrofit requirements. In order to provide an initial indication of where conflict may exist among the stakeholders, a HOQ analysis was completed for each stakeholder group individually to determine how the different stakeholder groups perceive that the case study building should be retrofitted, when compared to one another, the overall results, and to occupant satisfaction.

The same procedures implemented in the preceding section were performed using the responses provided by individuals within each of the tenant, owner, facility manager, designer, and environmental manager stakeholder groups. The individual HOQ analyses for each of the 5 stakeholder groups are included in Appendix J, and were calculated using data from Appendices B - F. A comparison summary of the technical targets matrix results for the final HOQ, each stakeholder group's HOQ, and the Occupant Satisfaction Survey is provided in Figure 17.

|                        |  | b. Mechanical System Retrofits | c. Electrical System Retrofits | d. Plumbing System Retrofits | e. Building Enclosure Retrofits | TOTAL        |
|------------------------|--|--------------------------------|--------------------------------|------------------------------|---------------------------------|--------------|
| Average                | $\Sigma$ Technical Importance            | 419                            | 357                            | 231                          | 371                             | <b>1379</b>  |
|                        | % Total Technical Importance             | 30%                            | 26%                            | 17%                          | 27%                             | <b>100%</b>  |
|                        | Relative Weight (1-5, 5 most important)  | 5.00                           | 4.26                           | 2.76                         | 4.43                            |              |
| Tenants                | $\Sigma$ Technical Importance            | 516                            | 387                            | 280                          | 397                             | <b>1579</b>  |
|                        | % Total Technical Importance             | 33%                            | 25%                            | 18%                          | 25%                             | <b>100%</b>  |
|                        | Relative Weight (1-5, 5 most important)  | 5.00                           | 3.76                           | 2.72                         | 3.85                            |              |
| Owners                 | $\Sigma$ Technical Importance            | 396                            | 328                            | 205                          | 313                             | <b>1242</b>  |
|                        | % Total Technical Importance             | 32%                            | 26%                            | 17%                          | 25%                             | <b>100%</b>  |
|                        | Relative Weight (1-5, 5 most important)  | 5.00                           | 4.14                           | 2.59                         | 3.95                            |              |
| Facility Managers      | $\Sigma$ Technical Importance            | 451                            | 479                            | 316                          | 450                             | <b>1696</b>  |
|                        | % Total Technical Importance             | 27%                            | 28%                            | 19%                          | 27%                             | <b>100%</b>  |
|                        | Relative Weight (1-5, 5 most important)  | 4.70                           | 5.00                           | 3.29                         | 4.70                            |              |
| Designers              | $\Sigma$ Technical Importance            | 368                            | 257                            | 130                          | 343                             | <b>1097</b>  |
|                        | % Total Technical Importance             | 34%                            | 23%                            | 12%                          | 31%                             | <b>100%</b>  |
|                        | Relative Weight (1-5, 5 most important)  | 5.00                           | 3.49                           | 1.77                         | 4.66                            |              |
| Environmental Managers | $\Sigma$ Technical Importance            | 366                            | 335                            | 227                          | 355                             | <b>1282</b>  |
|                        | % Total Technical Importance             | 29%                            | 26%                            | 18%                          | 28%                             | <b>100%</b>  |
|                        | Relative Weight (1-5, 5 most important)  | 5.00                           | 4.58                           | 3.10                         | 4.86                            |              |
| Occupant Satisfaction  | $\Sigma$ Occupant Satisfaction Points    | 72                             | 56                             | 69                           | 72                              | <b>268.2</b> |
|                        | % Dissatisfaction                        | 27%                            | 21%                            | 26%                          | 27%                             | <b>100%</b>  |
|                        | Relative Weight (1-5, 5 least satisfied) | 4.98                           | 3.87                           | 4.77                         | 5.00                            |              |

**Figure 17 – Technical Targets Matrix: Comparison by Stakeholder**

A graphical representation of the Figure 17 summary of technical targets data is provided in order to compare how much technical importance each stakeholder group placed on each sustainable retrofit measure. Figure 18 provides a comparison of relative weights for each retrofit measure according to each stakeholder group.



**Figure 18 – Comparison of Relative Weight by Stakeholder Group and Retrofit Measure**

Figure 18 illustrates that with little difference in relative weights, all stakeholders agree that the building is in need of mechanical system retrofits in order to meet their sustainable retrofit requirements. Building envelope retrofits also received high ratings for technical importance, with relative weights that ranked the building envelope as the second most important system to address in the averaged results and for most stakeholder groups. The tenants and

owners appear to be in disagreement with the rest of the group concerning the building envelope with lower scores; however, the tenant still ranked the building envelope as their second most important system to address. The owner did rank the building envelope in third place for relative weight (3.95); however, building envelope was not far behind the owner's second most important technical retrofit measure – the electrical system (4.14 relative weight). These observations also illustrate the purpose of the relative weight calculation for normalizing the results for an improved comparison across different stakeholders and retrofit measures.

The plumbing system was clearly ranked last in the HOQ analysis for all 5 stakeholder groups. The designers placed an especially low technical importance on this system. It was explained in Section 6.1 that the design team may be under the impression that plumbing system retrofits will not be required because of recently implemented water conservation upgrades and that the occupants are experiencing problems with the new upgrades. Figure 18 validates this observation between the designers and the occupants. Furthermore, the facility managers did allocate a technical importance rating for plumbing system retrofits that was much higher than the rest of the stakeholders. A possible explanation could be that the facilities managers are the individuals that are responding to the occupants' maintenance requests, and are therefore familiar with the maintenance issues in the building. However, the facilities managers still ranked plumbing system retrofits as their least important sustainable retrofit measure in meeting the sustainable retrofit requirements of the various stakeholders. This could indicate that the requirements for initiating sustainable retrofits in existing buildings do not align overall with the requirements for enhancing the building environment for the occupants.

The electrical system was ranked third, with the exception of the owner and facilities managers, in meeting the stakeholders' requirements for sustainably retrofitting the building.

Nevertheless, the owner's electrical system ranking (4.14) was essentially equal to their ranking for the technical importance of building envelope retrofits (3.95) and the facility managers' electrical system ranking (5.0) was almost equal to their number 2 ranking for the technical importance of mechanical system retrofits (4.7). No substantial conclusions can be drawn from this observation, except that the owner and facilities managers believe that their sustainable retrofit requirements can be met through enhancements to the electrical system.

In Section 6.1 the difference in occupant satisfaction with the overall HOQ results was explored in depth. It is important here to remind the reader that occupant satisfaction was based on a different set of requirements than the HOQ survey questions. The HOQ survey questions addressed technical importance of the four main retrofit measures in meeting sustainable retrofit requirements of the various stakeholders. The HOQ questionnaire was interested in determining what sustainable retrofits are most important in meeting a wide array of competing stakeholder requirements for sustainable retrofits, which included social and environmental requirements concerning the quality of the building environment. For example, the stakeholder requirements in the HOQ included economic objectives such as decreasing costs, ecological objectives such as conserving natural resources, and long term social objectives such as improving the image of the tenants and owner. In contrast, occupant satisfaction was based solely on the occupants' satisfaction with the building environment as satisfied by the four main technical systems.

It is interesting to note in the analysis of the technical targets results for individual stakeholder groups in this section, that the tenants' technical importance rating assignments for the building envelope and plumbing systems were substantially lower than the occupants' assignment of dissatisfaction with the building environment as provided by these same exact systems. The tenants and the occupants are essentially the same people representing the same

concerns. The six tenants that participated in the HOQ analysis were also among the 30 participants in the occupant satisfaction survey. These six tenants that participated in both surveys are senior level tenant representatives who are responsible for business operations within the building. Their responses to the occupant satisfaction survey demonstrated that they are certainly familiar with the building's environment, as these leaders provided many of the comments (available in Appendix L) regarding issues with the mechanical and plumbing systems. There are several possible explanations for the difference in the tenants' motivations for initiating sustainable retrofits and their satisfaction with the building environment. These possible explanations are as follows:

1. Plumbing system retrofits do not make a substantial impact on sustainable retrofit objectives as a whole, according to perceptions obtained in this case study.
2. The tenant HOQ participants misinterpreted the HOQ survey questions to be general in nature, rather than specific to the case study building.
3. Not enough stakeholder requirements for the plumbing system were included in the HOQ.
4. Sustainable retrofit requirements are not in alignment with requirements for enhanced building environments in this case study.

The fourth explanation suggests that motivations for initiating sustainable retrofits in existing buildings may be driven by factors other than enhancing the existing building environment for the occupants. This possibility will be explored further in the following sections of this chapter when the hierarchy of stakeholder requirements within each of the four main categories of sustainable retrofit measures is explored.

A comparison of the final HOQ technical targets matrix results for each individual stakeholder group introduced another level of analysis that illustrated how the HOQ can be used to identify where conflict may exist among competing stakeholder groups. Further awareness of existing conflict can enable team members to address discrepancies and overcome barriers that inhibit project teams from implementing the most beneficial sustainable retrofit features. Although this comparison demonstrated that stakeholders were mainly in agreement concerning the ranking of the building's sustainable retrofit requirements, this analysis verified that the retrofitting requirements for the different groups of stakeholders are indeed different in several cases.

The designers of the case study building were not aware that plumbing system retrofits were not performing as intended. Facility managers appeared to be more familiar with building discrepancies than the rest of the stakeholders and therefore need to be included in the sustainable retrofitting planning process. Additionally, these results indicated that the many stakeholder requirements for sustainable retrofit endeavors may not be in overall alignment with enhancing the building environment for occupants. For example, plumbing system retrofits were ranked low in HOQ technical importance by the tenants and facilities managers who were aware of the plumbing problems. In addition, tenant HOQ results differed from the tenants' occupant satisfaction survey results in regards to the importance of implementing retrofits to the plumbing and building envelope systems.

### *6.3 –Importance and Technical Importance Ratings for Competing Stakeholder Requirements*

The analysis and comparison of HOQ technical targets matrix results for individual stakeholder groups provided an initial indication of where conflict may exist and illustrated how

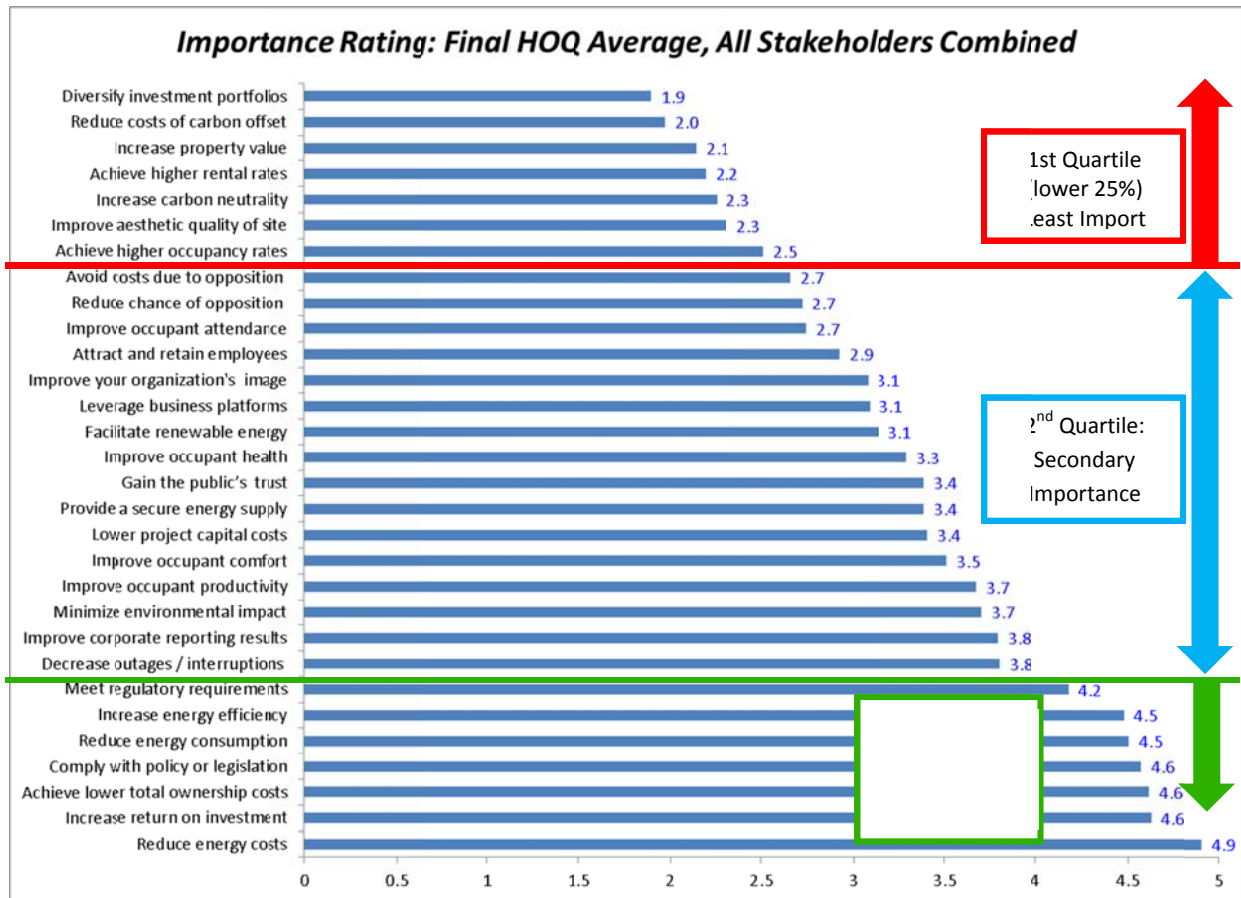
different stakeholder groups perceive that the case study building should be retrofitted. The technical targets matrix alone contains the integrated results for translating competing stakeholder requirements into prioritized technical focus areas. Thus far in analyzing the results of this research, the HOQ has been constructed, populated, and then slightly deconstructed in Section 6.2 in order to determine the differences of opinion in how the building should be retrofitted to indicate where conflict may exist.

In addition to the technical targets matrix, the full HOQ consisting of the stakeholder requirements, technical characteristics, and relationship matrices contains a substantial amount of useful information that can be further deconstructed in order to determine what stakeholder requirements were most influential in the decision to implement sustainable retrofits, relative to stakeholder perceptions of the four main technical measures considered in this research. In other words, the technical targets matrix indicated how the building should be retrofitted and the analysis in this section will indicate why the stakeholders believe the building should be sustainably retrofitted. Furthermore, areas in which additional conflict amongst stakeholders may exist can also be detected. The importance rating for each stakeholder requirement and the technical importance rating for each retrofit measure in meeting each stakeholder requirements will be evaluated in order to meet these objectives.

### *6.3.1 – Importance Rating*

The analysis in this section will begin by investigating the importance rating that was assigned to each of the 30 sustainable retrofit stakeholder requirements in column (a.) of the Stakeholder Requirements Matrix, as seen in Figure 14 on page 77. This overall importance rating for each stakeholder requirement was independent of the technical importance rating for each stakeholder requirement in the mechanical, electrical, plumbing, and building envelope

columns of the technical characteristics matrix. However, the importance rating is built into the technical importance through the application of the relationship rating using EQ. (1). A summary of the average importance rating assigned to each stakeholder requirement is displayed in Figure 19.



**Figure 19 – Importance Rating, Combined Results of all 5-Stakeholder Groups**

In an exploratory analysis of the visualized ordinal data using descriptive statistics techniques as described in Section 4.6.3, there are three categories in the ranking of data as indicated in Figure 19: items that have been assigned the highest importance ratings (3<sup>rd</sup> quartile), the lowest importance ratings (1<sup>st</sup> quartile), and those in-between (2<sup>nd</sup> quartile). The items with low importance ratings are likely to receive lower technical importance ratings, unless the technical relationship is rated as extremely strong. This situation would indicate that a

stakeholder requirement of low importance is explicitly fulfilled by one of the technical systems. The hierarchy of technical importance for each system will be explored in the sections that follow.

The analysis of data in this section will start with the items that received the lowest importance ratings in the first quartile. Stakeholder requirements of low importance are likely to receive low technical importance ratings for each building system; therefore, the low importance requirements will be analyzed to determine if they are relevant to this case study. To start with, the requirement for improving the aesthetic quality of the site is included in the list of the least important requirements. The reason for the low ranking of this requirement needs to be explored further during the investigation of the technical importance of each building system. However, at this point of the analysis, it can be speculated that stakeholders are only interested in building envelope upgrades to increase the environmental quality indoors based on occupant satisfaction feedback. However, the requirements to reduce the chance of opposition and the costs of dealing with opposition were ranked slightly more important than improving the aesthetic quality of the site. The requirement for improving appearance has been linked to avoiding opposition in that the surrounding community members and environmental interest groups are more likely to embrace a project that enhances the environment of the community (Singer et al. 2007; Savitz and Weber 2006).

The remaining requirements of low importance can be characterized as those requirements that do not necessarily apply to this case involving U.S. Federal Government employees and real property. The diversification of investment portfolios is not a concern at the Navy Installation's operating level; which is funded by taxpayer dollars that are allocated during a facilities budgeting process. Additionally, increasing property value is not typically a concern

for the stakeholders involved in this case study. The building is centrally located on a military installation with a low likelihood of real estate transactions, and in this situation the proceeds of the sale would not be available for use towards other budgetary needs on the base.

Higher occupancy and rental rates do not apply to this case study either, as described in the Section 5.2 description of the case study stakeholders. The Navy occupants reside in this building because they have assignments aboard the installation and reimbursement for their quarters is based on a housing allowance for their pay grade or upon local per diem rates. Reducing the costs of carbon offset and increasing carbon neutrality received low importance ratings as well. Currently, there is uncertainty regarding the future of the economic concerns of a carbon tax and the magnitude of the harmful effects of greenhouse gas emissions. (Nemry et al. 2010; Yudelso 2010). However, the stakeholder requirements that have been identified as the most important requirements for implementing sustainable retrofits in the case study building do have carbon emissions concerns built into them.

The stakeholder requirements that were ranked as most important according to all stakeholders can be categorized as those that save money, use less energy, and those that are required by law. Items that save energy have higher return on investments and are therefore more cost effective; which confirms the notion that the decision to sustainably retrofit a building is made based on purely economic grounds in this case study (Entrop et al. 2010; Yudelso 2010; McKinsey and Company 2008). The requirements for reducing energy costs, reducing energy consumption, increasing energy efficiency, and lowering total operating costs all appear in the top 6 most important objectives of the stakeholders in the third quartile.

As discussed in Section 4.4.1, similar stakeholder requirements such as those described above were not eliminated from the list of stakeholder requirements because different

requirements may have different meanings for different stakeholders. All stakeholders that participated in this study have demonstrated that they are aligned in regards to the objectives of saving money and energy, regardless of the various interpretations, motivations, and resulting social, environmental, and economic benefits. Furthermore, the stakeholders are aligned in regards to policy and law such as Executive Order 13423 (EO 13423 2007), that includes objectives that strengthen global environmental security for the sustainability of future generations of humans and animal species. This law applies to the federal case study building in this research and complying with policy, legislation, and the underlying objectives to conserve natural resources fell among the stakeholder requirements of highest importance. In addition, the requirements to minimize environmental impact, provide a secure energy supply, facilitate renewable energy, gain public trust, and improve your organizations image received importance ratings near the median level of 3.4. All of these requirements are objectives of the Executive Order.

None of the requirements that are typically associated with the enhancing the building environment for the tenants, such as decreasing outages and interruptions in the building, attracting and retaining employees, improving occupant productivity, comfort, health, and attendance fell among the most important requirement for initiating sustainable retrofits in the case study building according to all stakeholders combined. These soft and long term social, environmental, and economic benefits were all placed second to financial concerns. However, all of the four main technical measures considered in this research have the ability to meet these objectives for the tenants. In the following sections, the importance that was placed on the technical ability of each retrofit measure in fulfilling these objectives will be explored.

### 6.3.2 – Technical Importance of Mechanical System Retrofits

Now that the ranking of overall importance for individual stakeholder requirements has been discussed, the technical importance for the ability of each retrofit measure in meeting the stakeholder requirements will be explored starting with the mechanical system. This analysis will help determine what stakeholder requirements were most influential in the decision to implement sustainable retrofits to the mechanical system, according to the perceptions of the case study stakeholders. A summary of the average for the mechanical system technical importance rating assigned to each stakeholder requirement is displayed in Figure 20.

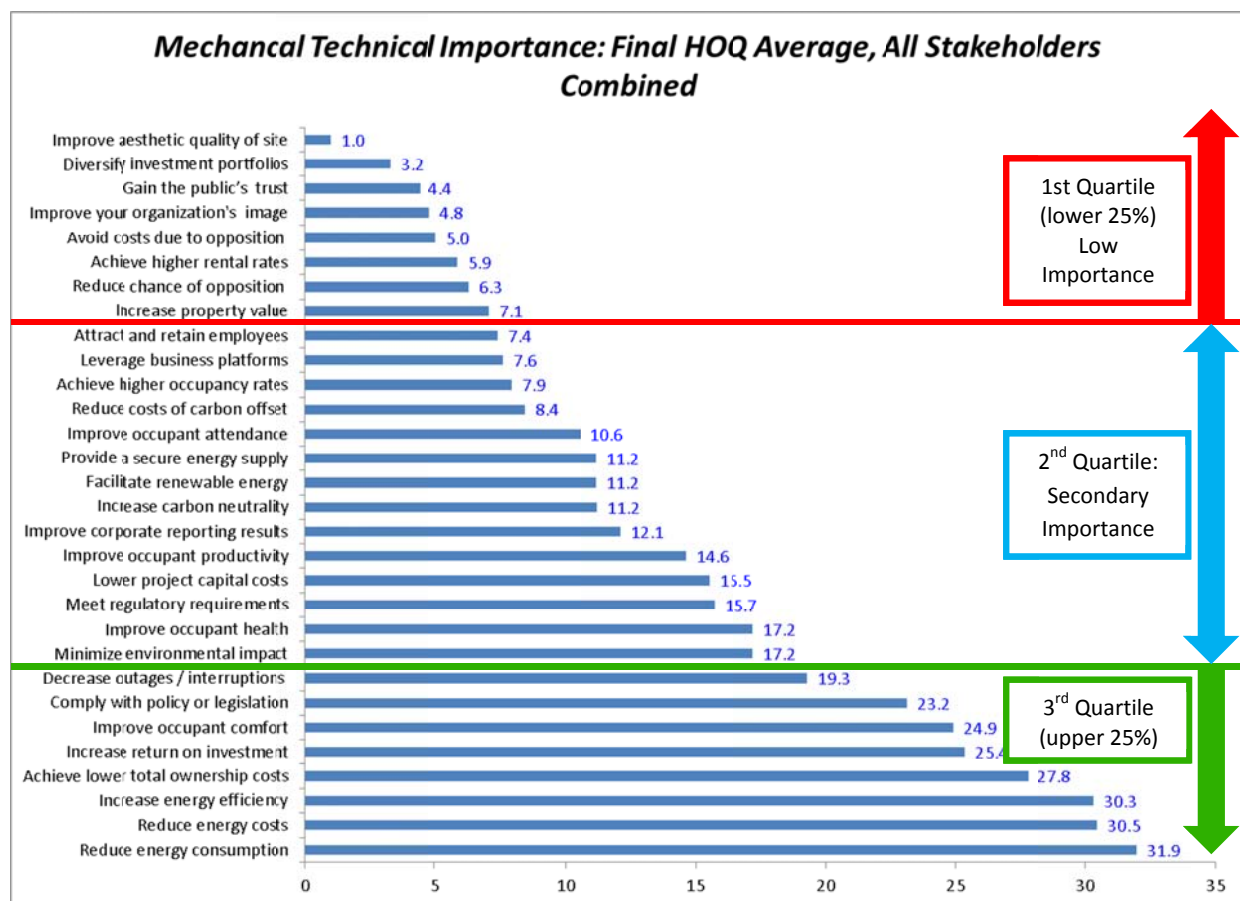


Figure 20 –Mechanical System Technical Importance Ratings, Combined Results

Figure 20 illustrates that the same stakeholder requirements for saving money, saving energy, and complying with policy and legislation are perceived as the most important requirements that can be achieved through mechanical system retrofits. This observation, combined with the HOQ technical targets matrix results, leads to the conclusion that the case study building is perceived to have an outdated and inefficient mechanical system. The mechanical system is perceived to have the best ability to save money, save energy, and therefore comply with EO 13423 (2007).

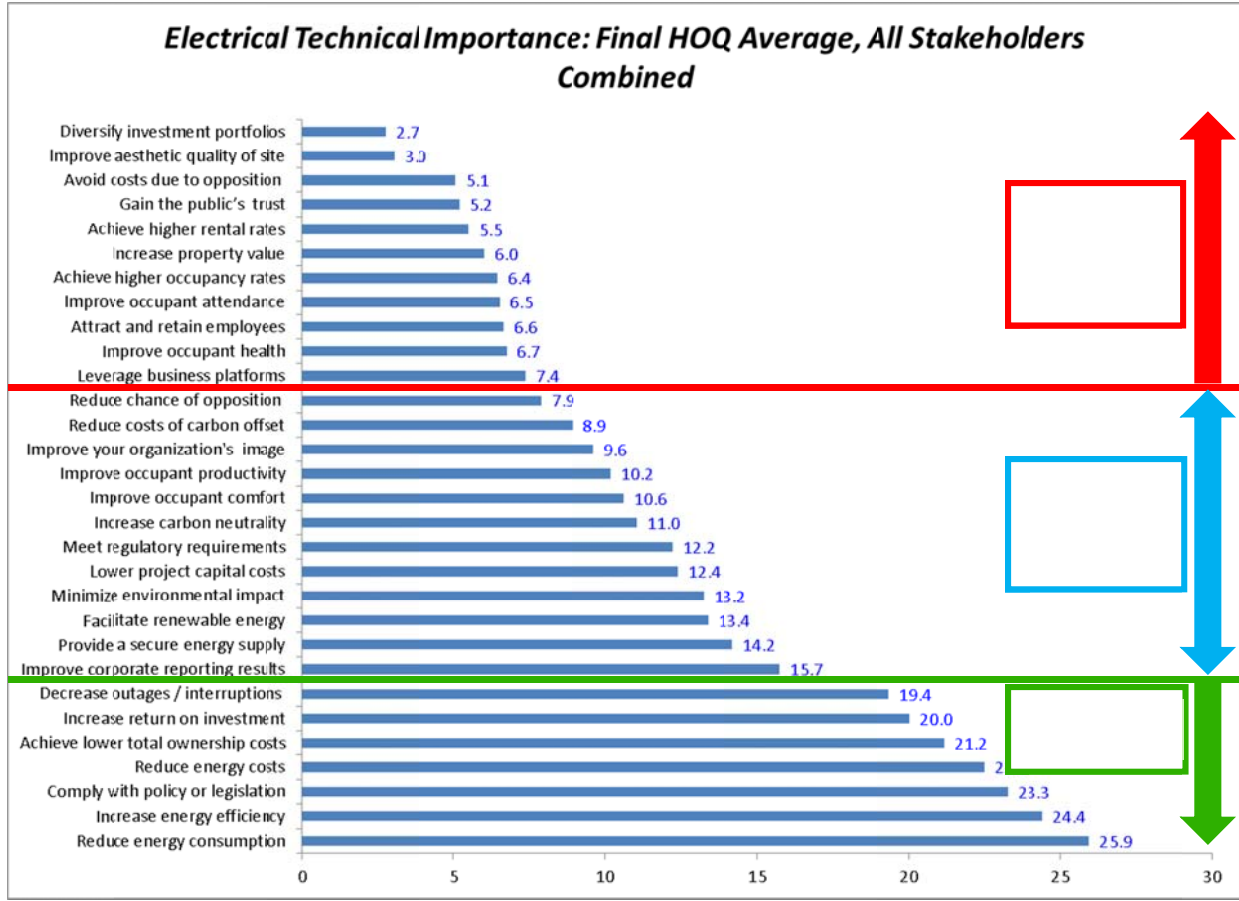
In addition, the mechanical system is perceived to have a strong ability to improve the building environment for the occupants. It should be noted that in the case of the mechanical system, that the benefit of improved occupant comfort and decreased outages and interruptions for the tenants made it into the third quartile, being in the category of stakeholder requirements with the highest mechanical system technical importance. As with the overall importance rating, the remaining benefits to the tenant as discussed in Section 6.3.1 are in the second quartile of technical importance ratings for mechanical system retrofits. According to the occupant satisfaction survey, the tenants are not satisfied with the existing capabilities of the mechanical system in providing a comfortable indoor environment. As a result, the stakeholder requirements for enhancing the building environment are not being met and received higher rankings for mechanical technical importance.

### *6.3.3 – Technical Importance of Electrical System Retrofits*

Similarly to mechanical system retrofits, the most important stakeholder requirements that can be met through electrical system retrofits are those that are in the categories of saving money, saving energy, and complying with policy and legislation. Figure 21, on page 97, demonstrates that the technical importance results for electrical system retrofits have very similar

trends to those for mechanical system retrofits, with the exception of lower scores. The electrical system was ranked as the third priority for the focus of design efforts and the highest area of occupant satisfaction in the technical targets matrix reviewed in Section 6.1. Therefore, the common stakeholder requirements of the tenants for an improved indoor environment and enhanced productivity received lower technical importance ratings for the electrical system.

Technical importance scores for the electrical system across all stakeholder requirements are generally lower and the gap between stakeholder requirements scores in the second quartile and those of low importance in the first quartile has decreased. Therefore, overall the stakeholders feel that the most important reasons to implement electrical system retrofits in the case study building are to save money, energy, and comply with policy. Beyond those requirements, there are no other overly important requirements or interesting trends to report for the electrical system. The electrical system stakeholder requirements that received medium technical importance scores in the second quartile are most likely perceived to be beneficial reasons for implementing electrical system retrofits; however not the primary reasons.

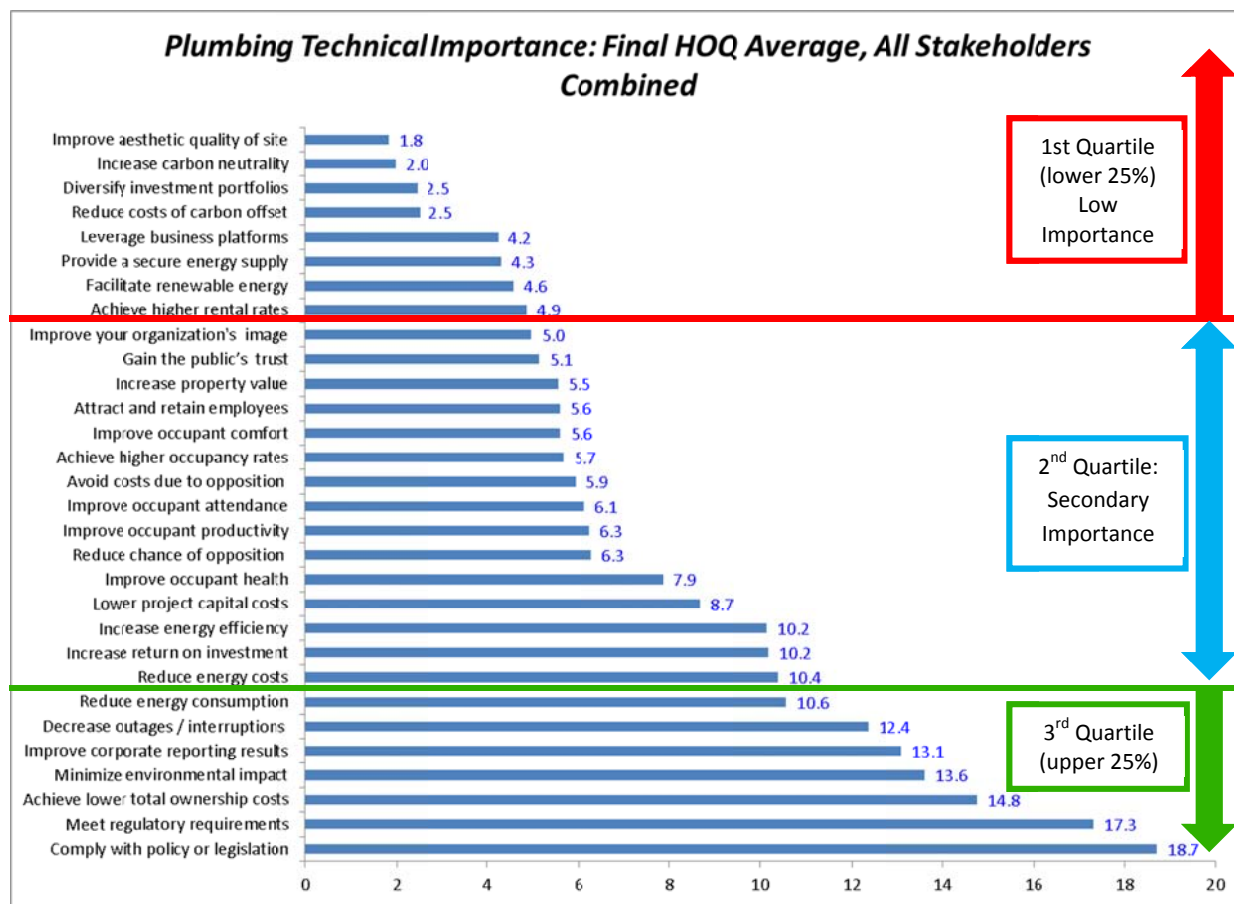


**Figure 21 – Electrical System Technical Importance Ratings, Combined Results**

*6.3.4 – Technical Importance of Plumbing System Retrofits*

The magnitude of the technical importance values for plumbing system retrofits has dramatically decreased as can be seen in Figure 22. The most important stakeholder requirements for implementing plumbing system retrofits in the case study building are to meet regulatory requirements and to comply with policy and legislation. Executive order 13423 (2007) sets goals for reducing water consumption by 2 percent annually from the baseline year of 2003. This mandated goal alone explains why those two stakeholder requirements are the most important for plumbing system retrofits. Furthermore, the plumbing system was the only retrofit

measure that included meeting regulatory requirements in the area of high technical importance.



**Figure 22 – Plumbing System Technical Importance, Combined Results**

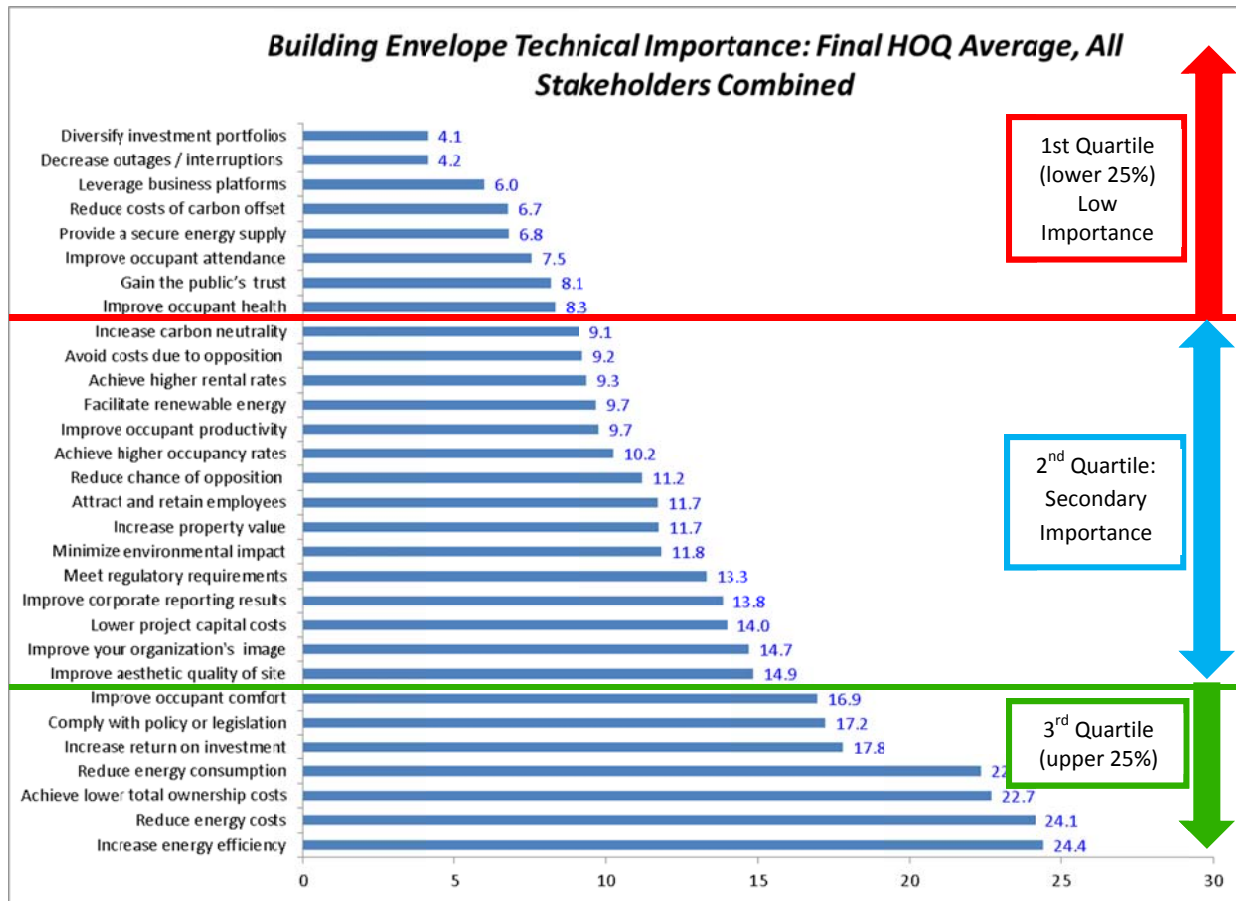
The requirements to meet regulatory requirements and minimize environmental impacts are ranked high on the stakeholders' list for the plumbing system, compared to the other retrofit measures, as plumbing system retrofits provide benefits that conserve water and decrease sewage treatment demands. The utility rates for water are not high compared to those for energy; therefore, requirements that involve saving costs received lower scores for plumbing system technical importance compared to the other retrofit measures. However, reduced energy costs and increased energy efficiency were ranked at the top of the second quartile, as the occupants

believe that energy and water are being wasted by the amount of time they wait for hot water to reach their showers.

The plumbing system received the lowest relative weight in the technical targets matrix, or in other words, was the least important focus area for sustainable retrofit efforts. However, as discussed in Sections 6.1 and 6.2, occupants were very dissatisfied with the plumbing system. In the analysis of this section, stakeholder requirements for improved productivity, health, and attendance, attracting and retaining employees, and increasing comfort received technical importance rankings in the second quartile. The tenant requirements for decreasing outages and interruptions did receive a high ranking in the third quartile as explained by the occupant satisfaction survey. The majority of stakeholder requirements for an enhanced environment for the tenants benefit may be perceived to have little influenced on the plumbing system. The requirements that were perceived to be influenced by the performance of the plumbing system (outages and interruptions) were not enough to increase the relative weight for plumbing system retrofits in the final HOQ results. In summary, plumbing system retrofits are not perceived to have the capability to save substantial costs or provide an enhanced building environment for occupants. However, the plumbing system has an ability to conserve natural resources and is expected to meet the minimum performance requirements of providing uninterrupted hot water for the occupants.

### *6.3.5 – Technical Importance of Building Envelope Retrofits*

Finally, the technical importance for the ability of building envelope retrofits in meeting individual stakeholder requirements was explored. A summary of the average for building envelope technical importance ratings is displayed in Figure 23.



**Figure 23 – Overall Building Envelope Technical Importance Ratings, Combined Results of all 5-Stakeholder Groups**

Once again, the stakeholders' sustainable retrofit requirements for saving costs, saving energy, and complying with policy appear in the list of requirements with the highest technical importance for building envelope retrofits. The technical importance values are slightly lower when compared to the values for the mechanical system; however, the stakeholder requirements that appear at the top of the list are the same. These results can be expected because building envelope retrofits were ranked a close second to mechanical system retrofits in the HOQ technical targets matrix results. The building envelope also received the lowest occupant satisfaction ratings. Therefore, the stakeholders perceive that both mechanical system retrofits and building envelope retrofits are closely related to saving costs, saving energy, and increasing occupant satisfaction with the building's environment.

The building envelope did receive lower ratings for the stakeholder requirements that are typically associated with enhancing the indoor building environment for the tenants, namely: decreasing outages, attracting employees, improving productivity, health, and attendance. However, the objective of increasing comfort for the tenants was ranked high, in the third quartile, directly below the top requirements of saving costs and energy. In addition, increasing occupant comfort was the only stakeholder requirement for the tenants' that received a high technical importance rating for the mechanical system. Therefore, the stakeholders perceive that increasing comfort is the most important sustainable retrofit requirements for the tenants, and that the other tenant requirements are secondary benefits beyond their primary benefit of making the tenant more comfortable as a result of sustainable retrofits. In other words, the stakeholders believe that if the tenants' primary needs of comfort are met, that they will experience fewer interruptions, fewer health concerns, and improved productivity.

It was discussed in Section 6.3.1 that the sustainable retrofit requirement to improve the aesthetics of the building's site received a low overall importance rating. As expected, this requirement received a much higher technical importance rating for the building envelope, at the top of the second quartile. Therefore, the stakeholders in this case study believe that the requirement to improve the appearance of the building is not that important; however, the building envelope is the only system that explicitly meets this requirement. This conclusion was also expected and the following are possible explanations:

1. The stakeholders believe that this building already has an aesthetically pleasing appearance.
2. The stakeholders are satisfied with their image, or do not believe that an aesthetically pleasing building will enhance their image.

3. There will not be opposition to a retrofit project in an existing building. The building has been in operation for years, is in need of upgrades anyway, and the surrounding community is accustomed to the appearance of the building and the existence of the building function in their neighborhood.
4. The aesthetics of the building are not important when budget, energy, and satisfying occupant needs are concerned.

Therefore, enhancing building aesthetics in order to minimize the environmental impact, improve the image of an organization, and avoid opposition from community stakeholders would only apply to new construction in this case study. Improving the aesthetics of this site alone would not justify the investment of resources for a sustainable retrofit endeavor in this case.

### *6.3.6 – Summary of Overall Importance and Technical Importance Ratings for the Competing Stakeholder Requirements*

Thus far, the HOQ importance and technical importance ratings were investigated to determine what stakeholder requirements were most important in each of the four main building systems considered in this research. In all systems, the stakeholder requirements to reduce operating costs, reduce energy consumption, and comply with policy were among the most important requirements for initiating sustainable retrofits in the case study building. These stakeholder requirements are typically shared amongst the tenants and the owners in this case study. Tenants typically reap the benefits of reduced energy costs, increased energy efficiency, reduced energy consumption, and lower total operating costs through lower utility bills. Owners may share some of these benefits depending on the leasing arrangements; however, owners are typically required to provide the upfront capital investment for sustainable retrofits in which the

tenant will realize the benefits. In this case study, both the owner and tenant have demonstrated that they consider complying with EO 13423 (2007) and its objectives to be extremely important. The primary requirements identified in this section were placed into the category of reduced cost, reduced energy consumption, and complying with policy. A summary of these results is provided in Table 8.

**Table 8 – Stakeholder Requirements: Category I – save costs, save energy, comply with policy, typically associated with owners**

| Category  | Requirement                    | Typical Stakeholder | Importance | Technical Importance |      |      |      |
|---|--------------------------------|---------------------|------------|----------------------|------|------|------|
|   |                                |                     |            | Mech                 | Elec | Plum | Envp |
| - Cost<br>- Energy<br>- Policy  | Reduce energy costs            | O, T                | H          | H                    | H    | M    | H    |
|   | Reduce energy consumption      | O, T, EV            | H          | H                    | H    | H    | H    |
|   | Increase energy efficiency     | O, T, EV            | H          | H                    | H    | M    | H    |
|   | Lower TOC                      | O, T                | H          | H                    | H    | H    | H    |
|   | Increase ROI                   | O, I                | H          | H                    | H    | M    | H    |
|   | Comply with policy/legislation | All                 | H          | H                    | H    | H    | H    |
|   | Meet regulatory requirements   | All                 | H          | M                    | M    | H    | M    |
| <ul style="list-style-type: none"> <li>- O = owner, I = investor, T = tenant, FM = facility managers, D = designers, EV = environmental managers</li> <li>- H = high importance ratings (3<sup>rd</sup> quartile), M = medium importance ratings (2<sup>nd</sup> quartile), L = low importance ratings (1<sup>st</sup> quartile)</li> </ul> |                                |                     |            |                      |      |      |      |

Therefore, the requirements listed in Table 8 are the main stakeholder requirements for initiating sustainable retrofits in the existing case study building. Furthermore, the above requirements are the main stakeholder requirements in each of the four sustainable retrofit categories. As discussed in Section 6.3.1, these findings confirm that the decision to sustainably retrofit an existing building is often made based upon purely economic grounds (Entrop et al. 2010; Yudelso 2010; McKinsey and Company 2008).

Furthermore, the decision to retrofit in this case study is driven by policy such as Executive Order 13423 (2007) “Strengthening Federal Environmental, Energy, and Transportation Management”, and strategic plans to meet policy such as the White House’s

(2011) “Blueprint for a Secure Energy Future”. Although these main requirements are driven by cost and higher level policy, the underlying principles behind the policy include conserving the natural environment and raw materials in an economically and fiscally sound manner for the sustainability of future generations. The results of this study demonstrate that a top down owner commitment towards sustainability does work and that the Federal Government is leading by example with their commitment. As a result of this policy, federal government stakeholders have been able to focus their efforts on conserving taxpayer dollars, reducing energy consumption, and reducing dependency on fossil fuels for the good of environmental and national security. The stakeholders in this case study have demonstrated that all other benefits that result from sustainable retrofits, although important, are not as important as the underlying principles of policy. Therefore, other benefits will be obtained as secondary benefits once the primary benefits are achieved.

The second category of sustainable retrofit requirements that was developed through observations made in Section 6.3 are the stakeholder requirements that are typically associated with enhancing the building environment for the occupants, as listed in Table 9.

**Table 9 – Stakeholder Requirements: Category II – Enhanced Building Environment for the Tenants**

| Category  | Requirement                   | Typical Stakeholder | Importance | Technical Importance |      |      |      |
|---|-------------------------------|---------------------|------------|----------------------|------|------|------|
|   |                               |                     |            | Mech                 | Elec | Plum | Envp |
| Enhance Bldg. Envirnmnt.  | Decrease outages/interruption | T, FM               | M          | H                    | H    | H    | L    |
|   | Improve Productivity          | T, FM               | M          | M                    | M    | M    | M    |
|   | Improve Comfort               | T                   | M          | H                    | M    | M    | H    |
| “Tenant Oriented Objectives”  | Improve Health                | T                   | M          | M                    | L    | M    | L    |
|   | Attract/retain employees      | T                   | M          | M                    | L    | M    | M    |
|   | Improve attendance            | T                   | M          | M                    | L    | M    | L    |
| <ul style="list-style-type: none"> <li>- O = owner, I = investor, T = tenant, FM = facility managers, D = designers, EV = environmental managers</li> <li>- H = high importance ratings (3<sup>rd</sup> quartile), M = medium importance ratings (2<sup>nd</sup> quartile), L = low importance ratings (1<sup>st</sup> quartile)</li> </ul> |                               |                     |            |                      |      |      |      |

Each stakeholder requirement in this second category of benefits that is typically associated with the tenants, mostly received secondary ratings for importance. The mechanical system and building envelope were most important for improving the comfort of the occupants. All systems except the building envelope were most important for decreasing outages and interruptions for the tenants. These findings are explained by the results in the technical targets matrix and by the occupant satisfaction survey. In summary, the stakeholders in this case study perceive that decreased outages and increasing comfort are the most important tenant oriented sustainable retrofit requirements, and that the other tenant oriented requirements that result from sustainable retrofits are secondary benefits. In other words, the stakeholders believe that if the tenants' primary needs of comfort are met, that they will experience fewer health concerns, less missed work days, and improved productivity.

The electrical system received a high technical importance rating for decreasing outages and interruptions; however, this finding is not explained by the occupant satisfaction survey or by the technical targets matrix analysis of Section 6.2. Overall, the electrical system was a low priority for the investment of project resources according to the HOQ and the Occupant Satisfaction Survey. Generally, fulfilling the tenant oriented requirements for an enhanced building environment was not perceived to be the most important stakeholder requirements.

The third category of sustainable retrofit requirements that was developed in this section includes objectives that were perceived to be of medium and low technical importance in most sustainable retrofit categories. These stakeholder requirements include those with long term, soft, or secondary objectives for many stakeholders such as environmental conservation, improving an organization's image, and avoiding costs. These "middle of the road" stakeholder

requirements that consistently received low to medium technical importance ratings are included in Table 10.

**Table 10 – Stakeholder Requirements: Category III – Not Most Important, “Middle of the Road”**

| Category  | Requirement                   | Typical Stakeholder | Importance | Technical Importance |      |      |      |
|---|-------------------------------|---------------------|------------|----------------------|------|------|------|
|   |                               |                     |            | Mech                 | Elec | Plum | Envp |
| Ecology   | Provide secure energy supply  | All                 | M          | M                    | M    | L    | L    |
|   | Facilitate renewable energy   | All                 | M          | M                    | M    | L    | M    |
|   | Meet regulatory requirements  | All                 | H          | M                    | M    | H    | M    |
|   | Minimize environmental impact | All                 | M          | M                    | M    | H    | M    |
|   | Improve aesthetics of site    | All                 | L          | L                    | L    | L    | M    |
| Image   | Improve corporate reporting   | O, T                | M          | M                    | M    | H    | M    |
|   | Improve your image            | O, T                | M          | L                    | M    | M    | M    |
|   | Reduce chance of opposition   | O, T                | M          | L                    | L    | M    | M    |
| Costs   | Reduce opposition costs       | O                   | M          | L                    | L    | M    | L    |
|   | Lower project capital costs   | O                   | M          | M                    | M    | M    | M    |
| <ul style="list-style-type: none"> <li>- O = owner, I = investor, T = tenant, FM = facility managers, D = designers, EV = environmental managers</li> <li>- H = high importance ratings (3<sup>rd</sup> quartile), M = medium importance ratings (2<sup>nd</sup> quartile), L = low importance ratings (1<sup>st</sup> quartile)</li> </ul> |                               |                     |            |                      |      |      |      |

The stakeholder requirements included in Table 10 have not been the topic of many discussions in this section and are not included in the most important stakeholder requirements from any of the technical building system, with the exception of the plumbing system. The plumbing system was viewed as the system that has the best ability to meet regulatory requirements and minimize environmental impacts. As discussed earlier, the sustainable plumbing system retrofits will conserve water, decrease sewage treatment demands, and decrease hot water heating requirements in the case study building. Furthermore, the plumbing system has the ability to improve corporate reporting in the area of water usage reduction for EO 13423 (2007). Beyond these observations, there are no other explanations evident from this research for the plumbing systems high ability to meet regulatory requirements. Furthermore, existing buildings are typically retrofitted to reset their service lives and regain original design efficiencies, not to meet regulatory requirements (Tainter 1995, Poel 2007).

As discussed in Section 6.3.5, improving the aesthetics of the building site in order to minimize environmental impacts, improve the image of an organization, and avoid opposition from community stakeholders would only apply to new construction in this case study. Improving the aesthetics of this site alone would not justify the investment of resources for a sustainable retrofit endeavor in this case. Therefore, these requirements were consistently rated low throughout the building systems.

The stakeholder requirements to minimize environmental impact, improve corporate reporting, and provide a secure energy supply were perceived to have medium to low importance for all technical systems, with the exception of the plumbing system as previously discussed. These requirements are underlying principles and requirements of EO 13423. Therefore, compliance with the executive order fulfills all of these requirements in addition to improving the image of the federal government and thus, these requirements are all secondary benefits. Furthermore, the stakeholder requirements to facilitate renewable energy and lower project capital costs also received medium importance ratings for all retrofit categories. A possible explanation is that the stakeholders do not believe that sustainable retrofits necessarily lower capital investment costs or facilitate the production of renewable energy. In this case study, the building is located in the Midwest which typically has the lowest renewable energy generation potential (Prowler 2012) and if renewable energy were produced it would most likely be produced off-site from this building with a small property footprint. In summary, the stakeholder requirements listed in Table 10 are not the most important in meeting the case study stakeholders' objectives. In addition, these stakeholder requirements may be the subject of the more abstract survey questions, with objectives that are already included in the fulfillment of higher stakeholder priorities.

Finally, the fourth category of sustainable retrofit requirements that was developed includes those that do not apply to this case study involving the federal government. These requirements can be seen in Table 11. Possible reasons were given in Section 6.3.1 for why the Table 11 requirements received low importance ratings. For example, the project is funded by taxpayer dollars, there is current uncertainty in the future of carbon taxes, and rental and occupancy rates are dictated by housing allowances and assignments of military personnel to the Navy installation. These requirements were also given low technical importance ratings and therefore do not apply to the case study explained in Section 6.3.1.

**Table 11 – Stakeholder Requirements: Category IV – Not Applicable to the Federal Government**

| Category   | Requirement                         | Typical Stakeholder | Importance | Technical Importance |      |      |      |
|--|-------------------------------------|---------------------|------------|----------------------|------|------|------|
|  |                                     |                     |            | Mech                 | Elec | Plum | Envp |
| Not Applicable   | Diversify investments               | O, I                | L          | L                    | L    | L    | L    |
|  | Leverage business platforms         | O, I                | M          | L                    | L    | L    | L    |
|  | Increase CO <sub>2</sub> neutrality | EV                  | L          | M                    | M    | L    | L    |
|  | Reduce CO <sub>2</sub> offset costs | O, EV               | L          | L                    | M    | L    | L    |
|  | Increase property value             | O, I                | L          | L                    | L    | L    | M    |
|  | Higher rental rates                 | O, I                | L          | L                    | L    | L    | L    |
|  | Higher occupancy rates              | O, T                | L          | L                    | L    | L    | M    |
| O = owner, I = investor, T = tenant, FM = facility managers, D = designers, EV = environmental managers<br>H = high importance (3 <sup>rd</sup> quart), M = medium importance (2 <sup>nd</sup> quart), L = low importance (1 <sup>st</sup> quartile) |                                     |                     |            |                      |      |      |      |

#### 6.4 – Effect of Stakeholder Type on the Retrofit Decision

Up until now it has been demonstrated in Chapter 6 that the HOQ model developed in this research contains a substantial amount of valuable information that can be used for several purposes. The HOQ was first used to elicit the most important technical requirements in response to competing stakeholder demands for implementing sustainable retrofit measures in the case study building. In addition to determining the most important technical focus areas, the HOQ model was used to determine what stakeholder requirements were most important for each

of those technical focus areas. And finally, these analyses provided an indication of where conflict may exist and illustrated how and why different stakeholder groups perceived that the case study building should be retrofitted.

In order to provide an additional determination of how the stakeholder type affects the ranking of their requirements, an additional investigation will be performed to investigate any conflict that may exist that could potentially act as a barrier to implementing sustainable retrofits in the case study building.

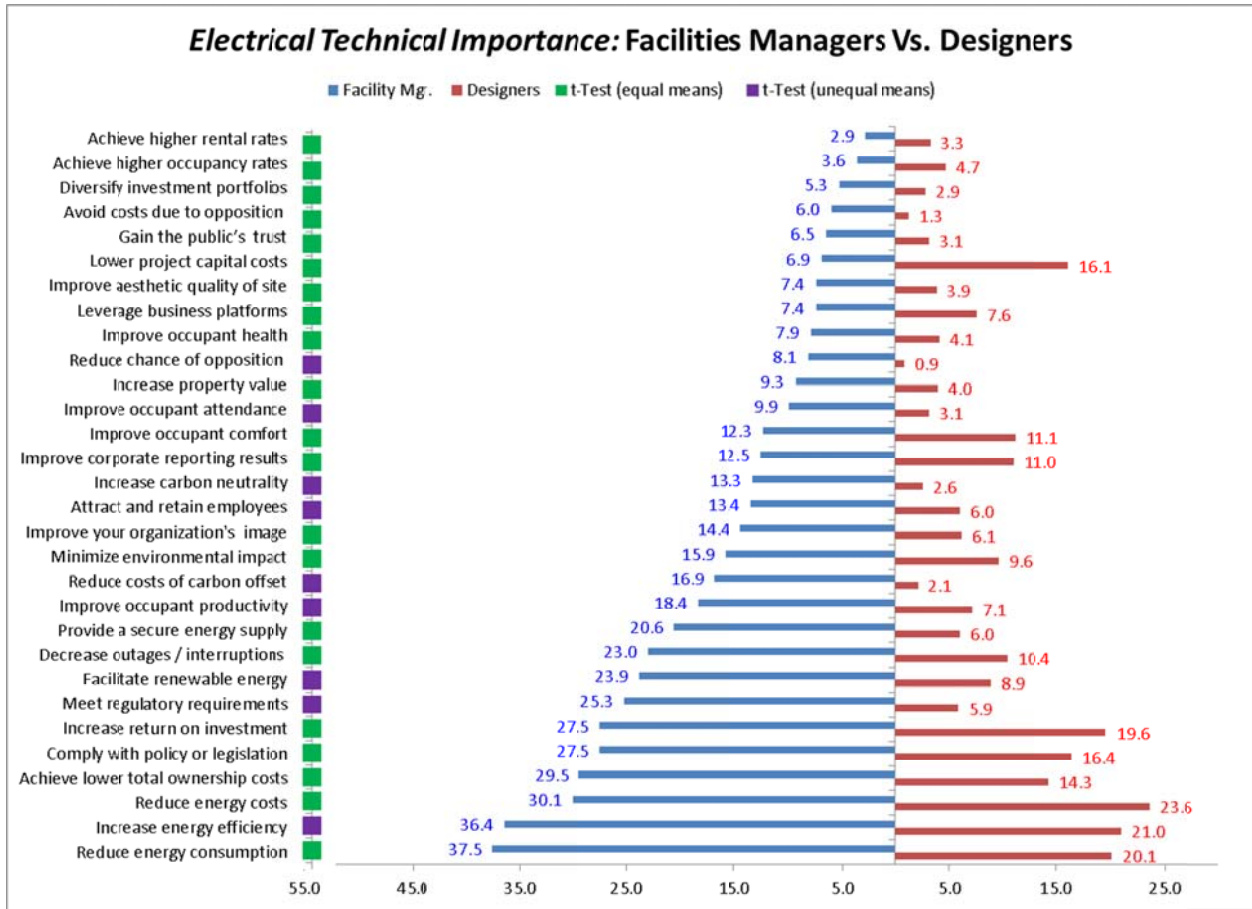
#### *6.4.1 – Facility Managers versus Designers, Electrical System Retrofits*

It was noted in Section 6.2 that the designers and facility managers had opposing perceptions regarding the importance of implementing electrical system retrofits. The designers HOQ assessment values were well below the average relative weight and the facility manager's assessed values were well above the average for the electrical system. Furthermore, facilities managers ranked the electrical system as most important and designers ranked the electrical system as third most important.

It is also interesting to examine the difference in perception between these two stakeholders because in literature these two groups of stakeholders have been described as having opposing objectives. Facilities managers play an important role in ensuring sustainably designed facilities continue to operate as intended after construction is complete, and sustainable construction guidance is focused on the objectives of the owners and tenants (Bosch and Pearce 2003). Furthermore, in addition to the tenants, facility managers are also customers of the final building product provided by the designers and constructors according to the principles of constructability (Yang et al. 2003).

Figure 24 on page 111 is provided to explore the differences in the perceptions of the facility managers versus those of the designers in regards to the technical importance of electrical system retrofits in the case study building. In Section 4.6.2 the  $t$  test was presented as the statistic that will be used to reflect agreement or disagreement between two independent stakeholder groups being compared to avoid comparing trivial results. Figure 24 contains information related to the magnitude and ranking of stakeholder requirements of the first stakeholder group being compared, the magnitude of stakeholder requirements according to the second stakeholder group that is being compared, and the results of the  $t$  test to indicate agreement or disagreement on the mean value of each stakeholder requirement between the two stakeholder groups being compared. Microsoft Excel  $t$  test calculations can be found in Table 30 of Appendix D.

For example, in Figure 24, the facility managers' number one retrofit requirement for the electrical system was to reduce energy consumption with a technical importance of 37.5. This stakeholder requirement for the designers' only had a technical importance of 20.1 which appears to be much lower. However, this requirement was in the 3<sup>rd</sup> quartile for each stakeholder and the results of the  $t$  test indicated that the means are the same when variance is taken into account. Therefore, the stakeholder groups are in agreement concerning this retrofit requirement. However, there are limitations in this analysis that must be considered. In this analysis of non-experimental ordinal data taken through judgment samples (not random), very small groups of 8 or fewer stakeholders are being compared. Therefore, the data cannot be assumed to be normally distributed.



**Figure 24 – Facility Managers Vs. Designers, Technical Importance of Electrical System Retrofits**

It can be seen in Figure 24 that according to the magnitude of technical importance and *t* test results, that the facility managers and designers are in disagreement concerning several of the individual stakeholder requirements. In this section, disagreement concerning stakeholder requirements that were consistently found to be the most important requirements in each of the sustainable retrofit categories (cost, energy, and policy) and tenant oriented requirements that were found to be of interest (comfort, less interruptions, productivity, health, attendance, attract employees) will be considered.

Requirements that did not produce noteworthy conclusions in Section 6.3 will not be considered, as the remaining requirements were found to either not apply or to be consistently

unimportant to the stakeholders overall. Since these remaining requirements produced a lot of variance and disparity in the responses, it is concluded that the survey questions were abstract or that the subject matter did not have the same meaning for different participants even though definitions were provided. Furthermore, possible reasons for the characterization of these requirements were also discussed in Section 6.3.

Table 12 and Table 13 provide a summary of where the disparity and a disagreement in ranking exist in each of the requirements of interest. This analysis will provide an indication as to whether these two groups agree with each other, and if they have a difference of opinion concerning the requirements that were found to be most important by the entire group of stakeholders.

**Table 12 – Facility Managers and Designer Comparison: Electrical System Technical Importance, Cost, Energy, and Policy**

| Technical Importance, Electrical System Retrofits  |                                |                     |                   |             |           |                   |                    |
|--|--------------------------------|---------------------|-------------------|-------------|-----------|-------------------|--------------------|
| Category   | Requirement                    | Typical Stakeholder | Facility Managers | FM Quartile | Designers | Designer Quartile | t-Test             |
| - Cost<br>- Energy<br>- Policy   | Reduce energy costs            | O, T                | 30.1              | 3           | 23.6      | 3                 | $\mu_t = \mu_o$    |
|  | Reduce energy consumption      | O, T, EV            | 37.5              | 3           | 20.1      | 3                 | $\mu_t = \mu_o$    |
|  | Increase energy efficiency     | O, T, EV            | 36.4              | 3           | 21.0      | 3                 | $\mu_t \neq \mu_o$ |
|  | Lower TOC                      | O, T                | 29.5              | 3           | 14.3      | 3                 | $\mu_t = \mu_o$    |
|  | Increase ROI                   | O, I                | 27.5              | 3           | 19.6      | 3                 | $\mu_t = \mu_o$    |
|  | Comply with policy/legislation | All                 | 27.5              | 3           | 16.4      | 3                 | $\mu_t \neq \mu_o$ |
|  | Meet regulatory requirements   | All                 | 25.3              | 3           | 5.9       | 2                 | $\mu_t = \mu_o$    |
| <ul style="list-style-type: none"> <li>- O = owner, I = investor, T = tenant, FM = facility managers, D = designers, EV = environmental managers</li> <li>- Red = disagreement, Blue = slight disagreement, Green = agreement</li> </ul> |                                |                     |                   |             |           |                   |                    |

**Table 13 – Facility Manager and Designer Comparison: Electrical System Technical Importance, Tenant Oriented Requirements**

| Technical Importance, Electrical System Retrofits  |                               |                     |                   |             |          |                   |                    |
|--|-------------------------------|---------------------|-------------------|-------------|----------|-------------------|--------------------|
| Category   | Requirement                   | Typical Stakeholder | Facility Managers | FM Quartile | Designer | Designer Quartile | t-Test             |
| Enhance Bldg. Envrmt.  | Decrease outages/interruption | T, FM               | 23.0              | 2           | 10.4     | 2                 | $\mu_t = \mu_o$    |
|  | Improve Productivity          | T, FM               | 18.4              | 2           | 7.1      | 2                 | $\mu_t \neq \mu_o$ |
|  | Improve Comfort               | T                   | 12.3              | 2           | 11.1     | 3                 | $\mu_t = \mu_o$    |
| “Tenant Oriented Objectives”   | Improve Health                | T                   | 7.9               | 2           | 4.1      | 2                 | $\mu_t = \mu_o$    |
|  | Attract/retain employees      | T                   | 13.6              | 2           | 6.0      | 2                 | $\mu_t \neq \mu_o$ |
|  | Improve attendance            | T                   | 9.9               | 2           | 3.1      | 1                 | $\mu_t \neq \mu_o$ |
| <ul style="list-style-type: none"> <li>- O = owner, I = investor, T = tenant, FM = facility managers, D = designers, EV = environmental managers</li> <li>- Red = disagreement, Blue = slight disagreement, Green = agreement</li> </ul> |                               |                     |                   |             |          |                   |                    |

Table 12 and Table 13 contain a comparison for quartile ranking and *t* test results.

Calculations for quartile assignments are available in the summary tables of Appendices B – F. This comparison in Table 12 and Table 13 indicates that facility managers and designers are in agreement concerning the comparative importance of each stakeholder requirement in being satisfied by electrical system retrofits. The requirements for saving cost, energy, and complying with policy were in the 3<sup>rd</sup> quartile (upper 25% of technical importance) for both stakeholders. The requirements for enhancing the building environment for the tenants were generally in the 2<sup>nd</sup> quartile (within 25% of the median value) for each stakeholder. Facility managers do perceive that improving productivity, attrition rates, and attendance are more important than the designers’ perceptions as indicated by the *t* test. However, these items generally received lower quartile rankings for both stakeholders. Both facility managers and designers believe that electrical system retrofits should be performed for the primary reasons of saving cost, energy, and complying with policy; and that enhancing the indoor building environment for the tenants is a secondary benefit that will result from these retrofits.

In summary, the discrepancy in this case was a matter of perception concerning the magnitude of technical importance for the electrical system as a whole, and not a matter of the hierarchy of requirements within the electrical system retrofit category. Facility managers disagreed with designers and had electrical system retrofits as their most important sustainable retrofit requirement, and designers disagreed with facility managers with the electrical system as their third most important retrofit requirement. However, the overall ranking for the stakeholder requirements within the electrical system was similar.

#### *6.4.2 – Opposing Stakeholder Groups*

In Section 6.2, different stakeholder perceptions regarding what technical systems are in need of sustainable retrofits were evaluated. This analysis indicated that all stakeholders were in agreement that the mechanical system is a top priority for retrofits. Furthermore, all stakeholder groups, with one sizeable exception, were in agreement that the second highest priority is the building envelope, the third priority is the electrical system, and the last priority is the plumbing system. Other exceptions regarding agreement with the order of ranking for each technical system were small in magnitude as can be seen for the owner and facility managers in Table 14 on page 115. The facility managers' number 2 and 3 rankings for mechanical system and building envelope retrofits, respectively, were essentially equal. The owner's number 2 and 3 rankings for electrical and building envelope retrofits, respectively, were also very close in value.

The only notable disagreement was between the designers and the facility managers. The designers ranked the electrical system in accordance with the rest of the stakeholders as their number three retrofit priority, but with the lowest relative weight out all stakeholders with a value of 3.49. Facility managers ranked the electrical system far different than the rest of the stakeholders as their number one priority with a relative weight of 5.0. This disagreement was

explored in Section 6.4.2.1 and it was determined that the hierarchy of stakeholder requirements within the category of electrical system retrofits were similar, and that facility managers simply placed a higher emphasis on the technical importance of the electrical system as a whole.

**Table 14 – Technical Targets Matrix, Comparison of Stakeholder Ranking**

|                        |  | b. Mechanical System Retrofits | c. Electrical System Retrofits | d. Plumbing System Retrofits | e. Building Enclosure Retrofits |
|------------------------|--|--------------------------------|--------------------------------|------------------------------|---------------------------------|
| Average                | Rank                                     | 1                              | 3                              | 4                            | 2                               |
|                        | Relative Weight (1-5, 5 most important)  | 5.00                           | 4.26                           | 2.76                         | 4.43                            |
| Tenants                | Rank                                     | 1                              | 3                              | 4                            | 2                               |
|                        | Relative Weight (1-5, 5 most important)  | 5.00                           | 3.76                           | 2.72                         | 3.85                            |
| Owners                 | Rank                                     | 1                              | 2                              | 4                            | 3                               |
|                        | Relative Weight (1-5, 5 most important)  | 5.00                           | 4.14                           | 2.59                         | 3.95                            |
| Facility Managers      | Rank                                     | 2                              | 1                              | 4                            | 3                               |
|                        | Relative Weight (1-5, 5 most important)  | 4.703                          | 5.00                           | 3.29                         | 4.697                           |
| Designers              | Rank                                     | 1                              | 3                              | 4                            | 2                               |
|                        | Relative Weight (1-5, 5 most important)  | 5.00                           | 3.49                           | 1.77                         | 4.66                            |
| Environmental Managers | Rank                                     | 1                              | 3                              | 4                            | 2                               |
|                        | Relative Weight (1-5, 5 most important)  | 5.00                           | 4.58                           | 3.10                         | 4.86                            |
| Occupant Satisfaction  | Rank                                     | 2                              | 4                              | 3                            | 1                               |
|                        | Relative Weight (1-5, 5 least satisfied) | 4.98                           | 3.87                           | 4.77                         | 5.00                            |

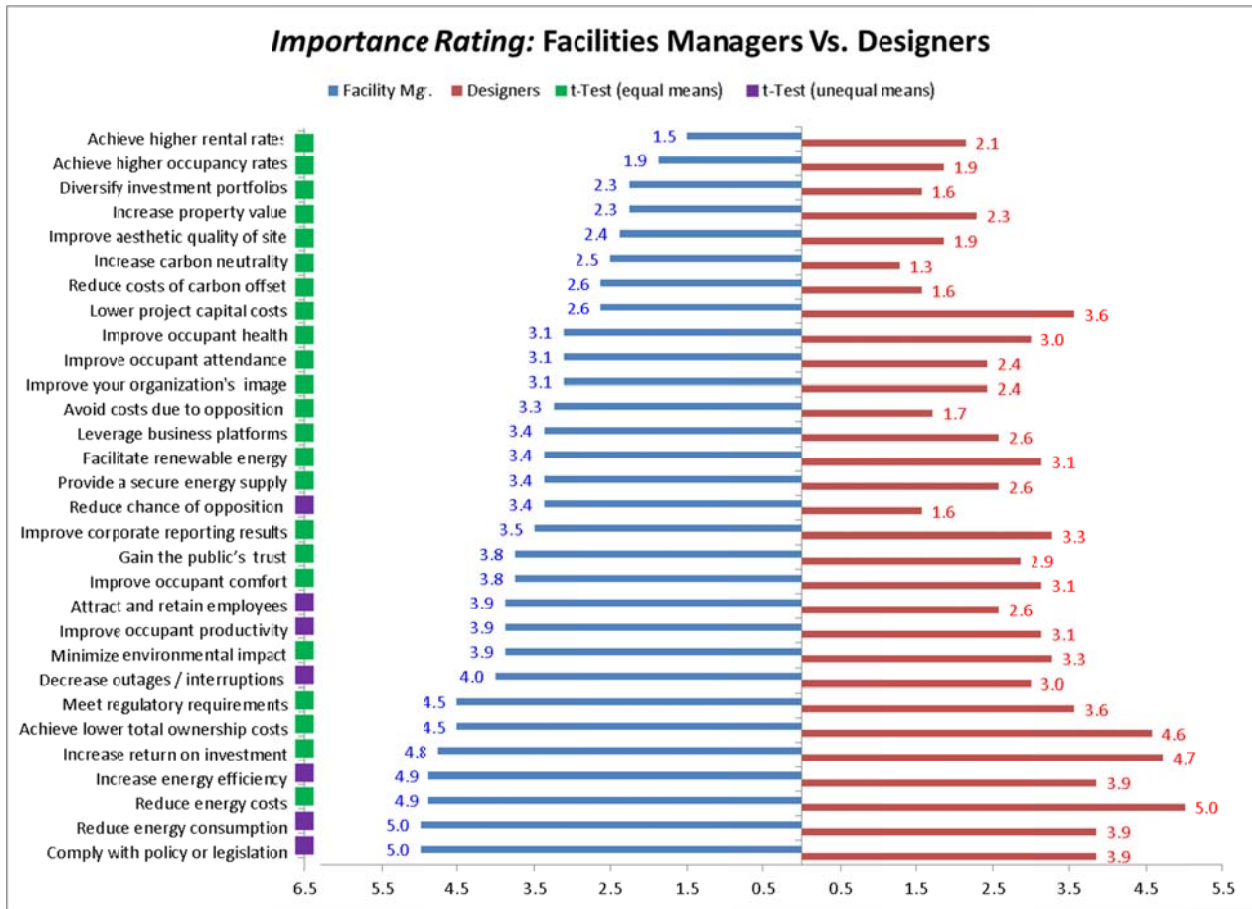
Furthermore, in Section 6.3, HOQ group decisions regarding the importance of each stakeholder requirement and the technical importance of each sustainable retrofit measure in meeting those requirements was explored. The results of this analysis demonstrated that stakeholder requirements for cost savings, energy savings, and compliance with policy were the primary reasons for implementing sustainable retrofits in each category; and that tenant oriented stakeholder requirements for improving the building environment were secondary benefits for

each category of sustainable retrofit. Thus, there was agreement regarding the type of retrofits to implement in the case study building and there was an indication of agreement concerning the hierarchy of each stakeholder requirement within the technical retrofit categories.

Therefore, one final type of analysis will be performed to explore how the stakeholder type affects the ranking of their requirements. The tables presented in Section 6.3.6 illustrated that the ranking of importance was typically aligned with the ranking of technical importance for each stakeholder requirement. The importance ratings were typically greater than or equal to the technical importance ratings for each requirement and each retrofit system. Therefore, it can be seen that the importance rating for each stakeholder requirement is a driving factor in the HOQ retrofit decision. Therefore, the importance ratings for two opposing pairs of stakeholders will be compared.

#### *6.4.2.1 – Facility Managers versus Designers, Importance Rating*

It was explained in Section 6.4.1 that facility managers and designers have been characterized as stakeholder groups who often have opposing objectives and viewpoints due to the nature of their respective functions. The importance rating for each stakeholder requirement, according to each stakeholder, and the  $t$  test results for the two groups are illustrated in Figure 25. Microsoft Excel  $t$  test calculations can be found in Table 23Table 30 of Appendix B.



**Figure 25 – Importance Rating, Facility Managers versus Designers**

As with the designer and facility manager comparison of electrical system technical importance, these stakeholders are also in disagreement concerning the importance of several of the individual stakeholder requirements. Table 15 and Table 16 are provided below to highlight the disparity in the magnitude of importance ratings as indicated by the *t* test and the order of ranking for the primary and secondary stakeholder requirements as determined by this research.

**Table 15 – Facility Managers and Designer Comparison: Importance Ratings – Cost, Energy, and Policy**

| Importance Rating Comparison, Facility Managers and Designers  |                                |                     |                   |             |           |                   |                    |
|--|--------------------------------|---------------------|-------------------|-------------|-----------|-------------------|--------------------|
| Category   | Requirement                    | Typical Stakeholder | Facility Managers | FM Quartile | Designers | Designer Quartile | t-Test             |
| - Cost<br>- Energy<br>- Policy   | Median Value                   |                     | 3.4               |             | 2.9       |                   |                    |
|  | Reduce energy costs            | O, T                | 4.9               | 3           | 5.0       | 3                 | $\mu_t = \mu_o$    |
|  | Reduce energy consumption      | O, T, EV            | 5.0               | 3           | 3.9       | 3                 | $\mu_t \neq \mu_o$ |
|  | Increase energy efficiency     | O, T, EV            | 4.9               | 3           | 3.9       | 3                 | $\mu_t \neq \mu_o$ |
|  | Lower TOC                      | O, T                | 4.5               | 3           | 4.6       | 3                 | $\mu_t = \mu_o$    |
|  | Increase ROI                   | O, I                | 4.8               | 3           | 4.7       | 3                 | $\mu_t = \mu_o$    |
|  | Comply with policy/legislation | All                 | 5.0               | 3           | 3.9       | 3                 | $\mu_t \neq \mu_o$ |
|  | Meet regulatory requirements   | All                 | 4.5               | 3           | 3.6       | 3                 | $\mu_t = \mu_o$    |
| <ul style="list-style-type: none"> <li>- O = owner, I = investor, T = tenant, FM = facility managers, D = designers, EV = environmental managers</li> <li>- Red = disagreement, Blue = slight disagreement, Green = agreement</li> </ul> |                                |                     |                   |             |           |                   |                    |

**Table 16 – Facility Manager and Designer Comparison: Importance Ratings – Tenant Oriented Requirements**

| Importance Rating Comparison, Facility Managers and Designers  |                               |                     |                   |             |           |                   |                    |
|--|-------------------------------|---------------------|-------------------|-------------|-----------|-------------------|--------------------|
| Category   | Requirement                   | Typical Stakeholder | Facility Managers | FM Quartile | Designers | Designer Quartile | t-Test             |
| Enhance Bldg. Environment<br>“Tenant Objectives”   | Median Value                  |                     | 3.4               |             | 2.9       |                   |                    |
|  | Decrease outages/interruption | T, FM               | 3.0               | 2           | 10.4      | 2                 | $\mu_t \neq \mu_o$ |
|  | Improve Productivity          | T, FM               | 3.1               | 2           | 7.1       | 2                 | $\mu_t \neq \mu_o$ |
|  | Improve Comfort               | T                   | 3.1               | 2           | 11.1      | 2                 | $\mu_t = \mu_o$    |
|  | Improve Health                | T                   | 3.0               | 2           | 4.1       | 2                 | $\mu_t = \mu_o$    |
|  | Attract/retain employees      | T                   | 2.6               | 2           | 6.0       | 2                 | $\mu_t \neq \mu_o$ |
|  | Improve attendance            | T                   | 2.4               | 2           | 3.1       | 2                 | $\mu_t = \mu_o$    |
| <ul style="list-style-type: none"> <li>- O = owner, I = investor, T = tenant, FM = facility managers, D = designers, EV = environmental managers</li> <li>- Red = disagreement, Blue = slight disagreement, Green = agreement</li> </ul> |                               |                     |                   |             |           |                   |                    |

Table 15 demonstrates that there is disagreement amongst facility managers and designers concerning the magnitude for the importance of saving energy and complying with policy; however, the two groups are in agreement concerning the requirements to increase ROI and decrease TOC. As with the electrical system, designers and facility managers are in agreement concerning the order of ranking for the importance of items that have to do with cost, energy, and policy.

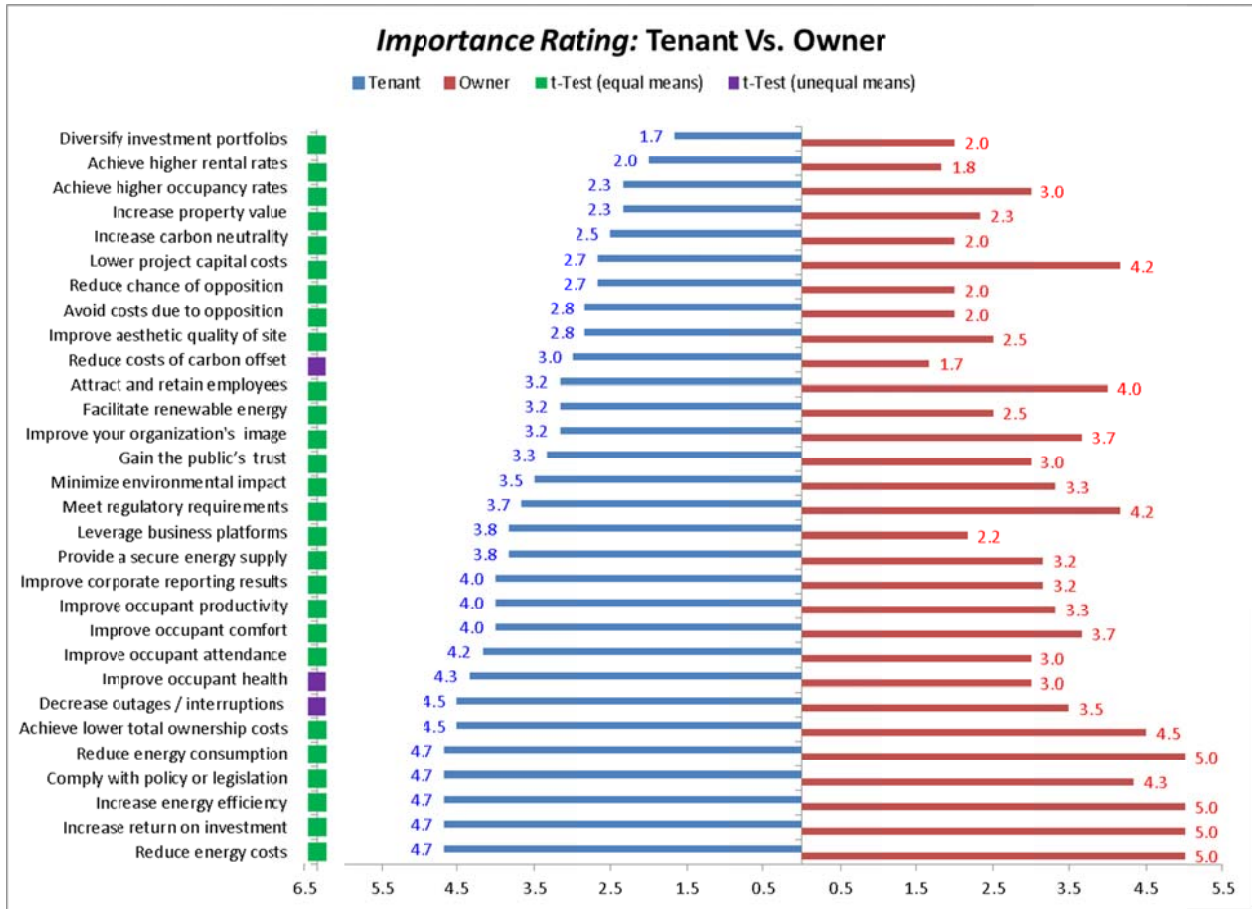
Table 16 reveals that facility managers and designers are in agreement that tenant requirements are secondary to the requirements associated with saving costs, saving energy, and complying with policy in regards to both magnitude and ranking. Once again, although the *t* test indicates a difference in the mean value of technical importance between the two stakeholders being compared, the quartile ranking assignments are the same. Therefore, in this case study, the designers and the facility managers are in agreement regarding the hierarchy of importance for the individual stakeholder requirements. These two stakeholders are aligned in that the primary sustainable retrofit requirements are to save cost, energy, and comply with policy; and that enhancing the building environment is secondary.

#### *6.4.2.2 – Tenants versus Owners, Importance Rating*

Throughout this document, owners and their tenants have been introduced as conflicting stakeholder groups. In addition, stakeholder requirements in this chapter have been categorized to be investments made by building owners mainly for the benefit of the tenant, as determined by numerous examples and the literature review of Chapter 2. It has been hypothesized throughout this research that tenants and owners are often in disagreement concerning how, when, and why a building should be sustainably retrofitted. Maximizing energy savings, ensuring project profitability, while pleasing the clients is often the most difficult aspect for building stakeholders

and this challenge often results in overlooking over half of the potential energy savings methods (Schneider and Rode 2010). Therefore, the import role of stakeholders in sustainable retrofit decisions and the alignment of their many requirements are critical issues that this study is addressing. For example, the owner of the building may be mainly interested in the requirements to increase their return on investment and reduce their capital investment outlays while the tenants may be interested in incentives such as lower utility bills, lower operating costs, improved occupant comfort, and increased productivity.

It can be seen in Table 14 on page 115 of Section 6.4.2 that the tenants and the owners developed similar results for technical sustainable retrofit priorities and that there were no substantial disagreements to note. However, disagreement may still exist concerning the primary reasons for embarking upon sustainable retrofits in the case study building regardless of the technical focus areas that were agreed upon. The importance rating for each stakeholder requirement, according to both the tenant and owner, and the  $t$  test results for the two groups are illustrated in Figure 26. Microsoft Excel  $t$  test calculations can be found in Table 22Table 30 of Appendix B.



**Figure 26 – Importance Rating, Tenant versus Owner**

In this case, Figure 26 shows that tenants and owners are in generally in agreement concerning the ranking of the importance of each stakeholder requirement. The tenants do feel that decreasing outages and improving health are more important than the owners perceive; however, still not as important as saving energy, costs, and complying with policy. The results are summarized in Table 17 and Table 18 for a detailed comparison.

**Table 17 – Tenant and Owner Comparison, Importance Ratings – Cost, Energy, and Policy**

| Importance Rating Comparison, Tenant and Owner   |                                |                     |        |          |       |          |                 |
|--|--------------------------------|---------------------|--------|----------|-------|----------|-----------------|
| Category   | Requirement                    | Typical Stakeholder | Tenant | Quartile | Owner | Quartile | t-Test          |
| - Cost<br>- Energy<br>- Policy   | Median Value                   |                     | 3.6    |          | 3.2   |          |                 |
|  | Reduce energy costs            | O, T                | 4.7    | 3        | 5.0   | 3        | $\mu_t = \mu_o$ |
|  | Reduce energy consumption      | O, T, EV            | 4.7    | 3        | 5.0   | 3        | $\mu_t = \mu_o$ |
|  | Increase energy efficiency     | O, T, EV            | 4.7    | 3        | 5.0   | 3        | $\mu_t = \mu_o$ |
|  | Lower TOC                      | O, T                | 4.5    | 3        | 4.5   | 3        | $\mu_t = \mu_o$ |
|  | Increase ROI                   | O, I                | 4.7    | 3        | 5.0   | 3        | $\mu_t = \mu_o$ |
|  | Comply with policy/legislation | All                 | 4.7    | 3        | 4.3   | 3        | $\mu_t = \mu_o$ |
|  | Meet regulatory requirements   | All                 | 3.7    | 2        | 4.2   | 3        | $\mu_t = \mu_o$ |
| <ul style="list-style-type: none"> <li>- O = owner, I = investor, T = tenant, FM = facility managers, D = designers, EV = environmental managers</li> <li>- Red = disagreement, Blue = slight disagreement, Green = agreement</li> </ul> |                                |                     |        |          |       |          |                 |

**Table 18 – Tenant and Owner Comparison, Importance Ratings – Tenant Oriented Requirements**

| Importance Rating Comparison, Tenant and Owner   |                               |                     |        |          |       |          |                    |
|--|-------------------------------|---------------------|--------|----------|-------|----------|--------------------|
| Category   | Requirement                   | Typical Stakeholder | Tenant | Quartile | Owner | Quartile | t-Test             |
| Enhance Bldg. Environment<br>“Tenant Oriented Objectives”  | Median Value                  |                     | 3.6    |          | 3.2   |          |                    |
|  | Decrease outages/interruption | T, FM               | 4.5    | 3        | 3.5   | 2        | $\mu_t \neq \mu_o$ |
|  | Improve Productivity          | T, FM               | 4.0    | 2        | 3.3   | 2        | $\mu_t = \mu_o$    |
|  | Improve Comfort               | T                   | 4.0    | 2        | 3.7   | 2        | $\mu_t = \mu_o$    |
|  | Improve Health                | T                   | 4.3    | 3        | 3.0   | 2        | $\mu_t \neq \mu_o$ |
|  | Attract/retain employees      | T                   | 3.2    | 2        | 4.0   | 2        | $\mu_t = \mu_o$    |
|  | Improve attendance            | T                   | 4.2    | 2        | 3.0   | 2        | $\mu_t = \mu_o$    |
| <ul style="list-style-type: none"> <li>- O = owner, I = investor, T = tenant, FM = facility managers, D = designers, EV = environmental managers</li> <li>- Red = disagreement, Blue = slight disagreement, Green = agreement</li> </ul> |                               |                     |        |          |       |          |                    |

Table 17 demonstrates that the tenants and the owners are mainly in alignment regarding the objective of saving cost, whether or not it is for the tenant’s or owner’s benefit. Table 17

also shows that the tenant and owner agree that saving energy and complying with policy are the most important sustainable retrofit objectives. Table 17 and Table 18 show that the tenant did place their requirements to decrease outages, interruptions, and improve health in their third quartile rankings ahead of meeting regulatory requirements. Therefore, there was slight disagreement and the tenants do believe these requirements are somewhat more important than the owner does. However, both the tenant and owner placed all requirements related to an enhanced building environment directly below the requirements for cost, energy, and policy in each of their rankings. Therefore, the tenants and owners in this case study have demonstrated that they are also aligned in their sustainable retrofit requirements. Although this finding is contradictory to a hypothesis of this research, Executive Order 13423 (2007) and strategic visions provided by the federal government such as the White House's (2011) "Blueprint for a Secure Energy Future" may provide the explanation for this finding.

All government employee stakeholders in this case study have demonstrated that they are aligned with the policy. Once again, the results of this study convey that a top down commitment towards the objectives of sustainability is a proven way to align stakeholders as demonstrated by the federal government. Furthermore, the tenants could be placing these objectives above their own, not only for the selfless purpose of improving the global environment from the macro perspective; but also because the tenants know that achieving these objectives will result in a retrofit project for their building from a micro-perspective.

### *6.5 – Social, Environmental, and Economic Sustainability Considerations*

It was explained in Section 6.1 that the HOQ is being displayed and discussed in two sections, one HOQ that includes the four main technical sustainable retrofit measures (mechanical, electrical, plumbing, and envelope) and one HOQ that includes the three main

sustainability considerations (social, environmental, and economic) in the technical targets matrix. In this section, the HOQ that includes the main sustainability consideration for social, environmental, and economic impacts will be analyzed.

The stakeholder requirements that were identified in the literature review of Chapter 2 are all motivations that have qualities that can be attributed to each category of social, environmental, economic, and technical consideration. Throughout the literature review, researchers have explored and debated the many benefits provided by sustainable building features and have attempted to translate many long-term environmental and social benefits into quantifiable economic returns to assist building owners in justifying the sustainable retrofit decision (Juan et al. 2010; Rey 2004). Furthermore, researchers have determined that the decision to sustainably retrofit is most often made based purely on short-term economic grounds without taking into account the long-term social and environmental impacts of the decision that are difficult to quantify (Yudelso 2010; Oreszcyn and Lowe 2010). According to Klotz and Hormon (2010), the impact of sustainable buildings on social, environmental, and economic considerations is understated. Gaterell and McEvoy (2005) concluded that although decisions are often based on purely economic grounds regarding the payback for energy savings techniques, moving-forward with these decisions will still have a significant impact on long-term social, environmental, and economic concerns.

Therefore, this HOQ analysis was conducted to provide an indication of how the main requirements of the different building stakeholders are perceived to have an impact on each of the three sustainability considerations (Social, Environmental, and Economic); now that the main stakeholder requirements from each sustainable retrofit category and how the stakeholder type effects the sustainable retrofit decision have been determined. This analysis will provide an

assessment of the perception that exists concerning the balance between the social, environmental, and economic aspects of sustainable development practices in this case study.

### *6.5.1 – House of Quality for Social, Environmental, and Economic Considerations*

Similarly to the HOQ that was presented in Section 6.1, the HOQ survey responses for each individual and a summary of the average responses for this section are also available in Appendices G – I. The average response for each question in this HOQ were also calculated using procedures that equally account for each stakeholder group using EQ. (5), as described in Sections 4.6.1 and 6.1 and demonstrated on pages J-7 to J-11. These averages were entered into the importance rating, relationship rating, and technical importance fields as seen in the HOQ model in Figure 27 below. A summary of the calculations is available in Appendices G - J.

| House of Quality: Average Results, All Stakeholders Combined |                                     |                             |   |      |                               |      |                                    |      |  |
|--|-------------------------------------|-----------------------------|---|------|-------------------------------|------|------------------------------------|------|--|
| Potential Stakeholder Requirements:                          |                                     | a. Importance (1 - 5 scale) | Sustainability Considerations (0-1-3-5-9 scale) |      |                               |      |                                    |      |  |
|  |                                     |                             | f. Social Impact                                |      | g. Environmental Impact       |      | h. Economic Impact                 |      |  |
|  |                                     |                             | f. Technical Importance (Social)                |      | g. Technical Importance (Env) |      | h. Technical Importance (Economic) |      |  |
| 1  | Reduce energy costs                 | 4.9                         | 4.0   | 19.4 | 3.9                           | 19.1 | 7.4                                | 36.2 |  |
| 2  | Increase return on investment       | 4.6                         | 2.0   | 9.2  | 1.2                           | 5.2  | 6.5                                | 30.6 |  |
| 3  | Minimize environmental impact       | 3.7                         | 6.0   | 22.2 | 6.6                           | 24.4 | 2.0                                | 7.9  |  |
| 4  | Improve your organization's image   | 3.1                         | 4.7   | 15.1 | 3.9                           | 12.5 | 4.1                                | 13.4 |  |
| 5  | Improve occupant comfort            | 3.5                         | 3.6   | 13.4 | 1.8                           | 6.6  | 2.6                                | 9.1  |  |
| 6  | Increase energy efficiency          | 4.5                         | 3.5   | 16.4 | 4.4                           | 20.2 | 6.7                                | 31.1 |  |
| 7  | Increase carbon neutrality          | 2.3                         | 4.5   | 11.4 | 5.9                           | 13.9 | 1.8                                | 3.9  |  |
| 8  | Achieve lower total ownership costs | 4.6                         | 1.5   | 7.0  | 1.6                           | 7.4  | 6.3                                | 29.3 |  |
| 9  | Meet regulatory requirements        | 4.2                         | 3.4   | 13.7 | 5.5                           | 24.2 | 2.2                                | 9.2  |  |
| 10   | Comply with policy or legislation   | 4.6                         | 3.4   | 15.3 | 4.5                           | 21.0 | 3.6                                | 17.3 |  |
| 11   | Improve aesthetic quality of site   | 2.3                         | 4.2   | 10.4 | 2.3                           | 5.9  | 2.3                                | 4.3  |  |
| 12   | Improve occupant productivity       | 3.7                         | 3.3   | 12.8 | 1.9                           | 7.4  | 4.5                                | 17.8 |  |
| 13   | Reduce chance of opposition         | 2.7                         | 4.8   | 13.9 | 3.5                           | 10.4 | 3.8                                | 12.1 |  |
| 14   | Increase property value             | 2.1                         | 1.0   | 1.9  | 1.2                           | 2.3  | 6.0                                | 14.0 |  |
| 15   | Reduce energy consumption           | 4.5                         | 4.9   | 22.4 | 4.7                           | 21.8 | 6.6                                | 30.3 |  |
| 16   | Provide a secure energy supply      | 3.4                         | 3.5   | 12.1 | 3.6                           | 13.5 | 3.9                                | 13.2 |  |
| 17   | Facilitate renewable energy         | 3.1                         | 5.0   | 16.2 | 5.6                           | 17.5 | 3.2                                | 11.5 |  |
| 18   | Lower project capital costs         | 3.4                         | 1.4   | 5.0  | 1.3                           | 4.8  | 6.7                                | 21.6 |  |
| 19   | Reduce costs of carbon offset       | 2.0                         | 3.7   | 9.1  | 5.1                           | 12.2 | 3.4                                | 7.6  |  |
| 20   | Achieve higher rental rates         | 2.2                         | 1.3   | 2.4  | 0.6                           | 1.0  | 5.2                                | 12.3 |  |
| 21   | Achieve higher occupancy rates      | 2.5                         | 1.5   | 4.4  | 0.8                           | 1.7  | 4.7                                | 12.8 |  |
| 22   | Avoid costs due to opposition       | 2.7                         | 4.2   | 11.5 | 2.9                           | 7.6  | 3.9                                | 11.7 |  |
| 23   | Gain the public's trust             | 3.4                         | 4.3   | 15.0 | 3.5                           | 12.2 | 3.6                                | 13.4 |  |
| 24   | Decrease outages / interruptions    | 3.8                         | 2.1   | 8.4  | 0.5                           | 2.0  | 4.0                                | 16.1 |  |
| 25   | Attract and retain employees        | 2.9                         | 3.1   | 9.7  | 1.8                           | 6.4  | 3.8                                | 11.6 |  |
| 26   | Improve occupant attendance         | 2.7                         | 2.5   | 8.9  | 1.0                           | 3.6  | 3.9                                | 12.8 |  |
| 27   | Improve occupant health             | 3.3                         | 3.9   | 14.2 | 2.3                           | 7.8  | 3.2                                | 11.5 |  |
| 28   | Improve corporate reporting results | 3.8                         | 4.4   | 17.7 | 2.9                           | 12.0 | 4.8                                | 18.5 |  |
| 29   | Diversify investment portfolios     | 1.9                         | 1.5   | 3.3  | 0.9                           | 2.1  | 4.0                                | 9.7  |  |
| 30   | Leverage business platforms         | 3.1                         | 2.8   | 9.7  | 1.4                           | 4.5  | 4.4                                | 15.5 |  |
| Σ Technical Importance                                       |                                     |                             | 352   |      | 311                           |      | 466                                |      |  |
| Relative Weight (1-5, 5 most important)                      |                                     |                             | 3.78  |      | 3.34                          |      | 5.00                               |      |  |

Figure 27 - HOQ for Sustainability Considerations, Equal Representation of All Stakeholder Groups

The results presented in the technical targets matrix of Figure 27 indicate that the stakeholder requirements considered in this research have the biggest impact on economic considerations, with a relative weight of 5.0. In other words, sustainable retrofit objectives in this case study are primarily motivated by economic concerns. Stakeholder objectives in this research are perceived to have secondary impacts on social considerations and have the least amount of impact on environmental considerations according to the overall relative weights of 3.78 and 3.34 respectively. Figure 28 is presented below to provide an indication of agreement or disagreement amongst the stakeholder groups concerning these final results. The individual HOQ's that are summarized in Figure 28 are available in Appendix J.

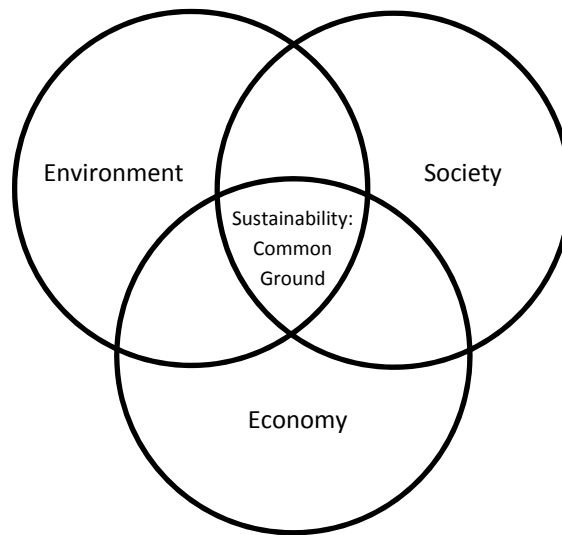
|                        |   | f. Social Impact | g. Environmental Impact | h. Economic Impact | TOTAL       |
|------------------------|---|------------------|-------------------------|--------------------|-------------|
| Average                | $\Sigma$ Technical Importance           | 352              | 311                     | 466                | <b>1130</b> |
|                        | % Total Technical Importance            | 31%              | 28%                     | 41%                | <b>100%</b> |
|                        | Relative Weight (1-5, 5 most important) | 3.78             | 3.34                    | 5.00               |             |
| Tenants                | $\Sigma$ Technical Importance           | 433              | 413                     | 574                | <b>1420</b> |
|                        | % Total Technical Importance            | 30%              | 29%                     | 40%                | <b>100%</b> |
|                        | Relative Weight (1-5, 5 most important) | 3.77             | 3.59                    | 5.00               |             |
| Owners                 | $\Sigma$ Technical Importance           | 300              | 210                     | 411                | <b>921</b>  |
|                        | % Total Technical Importance            | 33%              | 23%                     | 45%                | <b>100%</b> |
|                        | Relative Weight (1-5, 5 most important) | 3.65             | 2.56                    | 5.00               |             |
| Facility Managers      | $\Sigma$ Technical Importance           | 529              | 404                     | 575                | <b>1508</b> |
|                        | % Total Technical Importance            | 35%              | 27%                     | 38%                | <b>100%</b> |
|                        | Relative Weight (1-5, 5 most important) | 4.60             | 3.51                    | 5.00               |             |
| Designers              | $\Sigma$ Technical Importance           | 214              | 198                     | 299                | <b>711</b>  |
|                        | % Total Technical Importance            | 30%              | 28%                     | 42%                | <b>100%</b> |
|                        | Relative Weight (1-5, 5 most important) | 3.57             | 3.32                    | 5.00               |             |
| Environmental Managers | $\Sigma$ Technical Importance           | 285              | 331                     | 473                | <b>1088</b> |
|                        | % Total Technical Importance            | 26%              | 30%                     | 43%                | <b>100%</b> |
|                        | Relative Weight (1-5, 5 most important) | 3.02             | 3.50                    | 5.00               |             |

**Figure 28 – Technical Targets Matrix, Sustainability Considerations**

According to Figure 28, all stakeholders agree that the sustainable retrofit requirements considered in this research have the biggest impact on economic considerations and with one exception, social considerations are secondary and environmental considerations are last. Refreshingly, environmental compliance managers determined that the stakeholder requirements have a bigger impact on environmental considerations than on social considerations. Furthermore, on average the social and environmental considerations were assigned relative weights in the range of 3.34 to 3.78. These scores are substantially lower than that for economic considerations, with a relative weight of 5.0. According to the HOQ surveys in this research, social and environmental impacts are “fairly” to “very” important, while economic impacts are “extremely” important.

However, the three sustainability considerations are not that far out of balance. According to the percent of technical importance results in Figure 28, social, environmental, and economic impacts each have 31, 28, and 41 percent of the technical importance respectively. Ideally, according to the principles of sustainability, the impacts on society, the environment, and the economy should all be equal (33.33% each) and have the maximum amount of possible overlap. In other words, “profit would be meeting common good” if there were equal magnitudes of impact on social, environmental, and economic considerations and the impacts were shared amongst all sustainability considerations. Furthermore, the benefits provided by social and environmental impacts would provide economic returns in the long run (Savitz and Weber 2006). For example, owners that implement sustainable retrofits that may not result in an attractive return on investment may still obtain benefits that have economic returns in the future such as an improved image, increased public trust, avoidance of future carbon taxes, or avoided legal costs due to opposition (Singer et al. 2007; Savitz and Weber 2006; Gluch and Baumann 2003).

In summary, this case study demonstrates that researchers are correct, the retrofit decision was primarily based on economic factors; however, social and environmental considerations are on the forefront of federal policy and important to the case study stakeholders. In other words, this case study demonstrates that progress is being made towards the principles of sustainability. Figure 29 illustrates these principles.



**Figure 29 – Sustainability: The Common Ground (adapted from Savitz and Weber 2006)**

To illustrate the perception of the common ground in this case study, the hierarchy of impacts made by stakeholder requirements on the main sustainability considerations will be explored in Section 6.5.2. Several possible explanations for the HOQ results obtained in this section have been discussed, and these explanations are summarized in the following list:

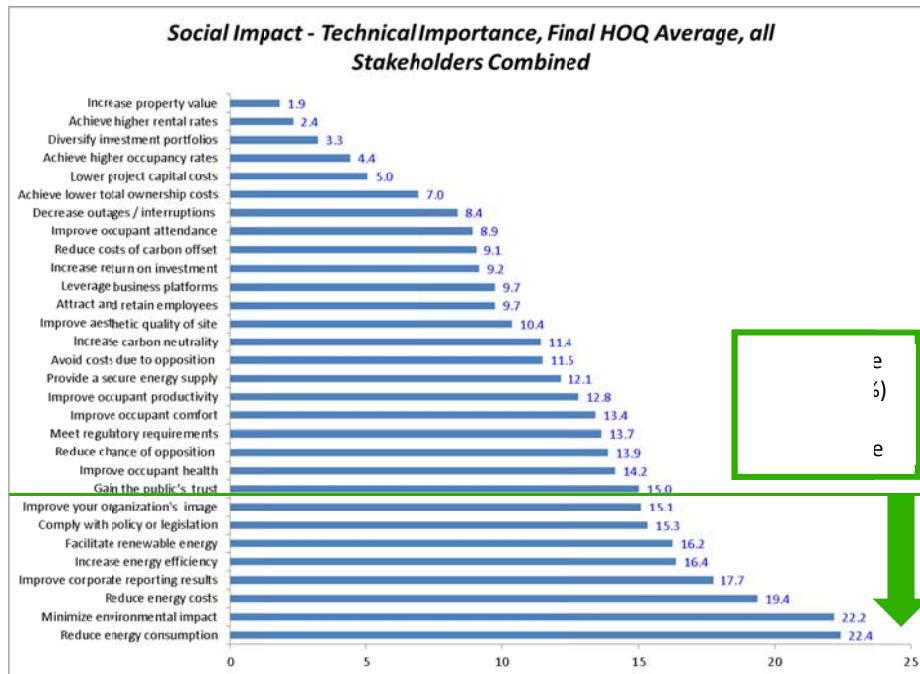
1. Stakeholder requirements in this case study are focused on economic issues (i.e. there are more economic objectives than social and environmental objectives).

2. Case study stakeholders perceive that economic concerns are the primary motivation behind their sustainable retrofit decisions. However, the federal policy that is driving economic decisions was developed to address social and environmental problems as well.
3. Although the case study stakeholders' primary objectives are for economic impacts, the case study stakeholders have overlap between social, environmental, and economic concerns. Therefore, the stakeholders' objectives are approaching a common ground for sustainability.

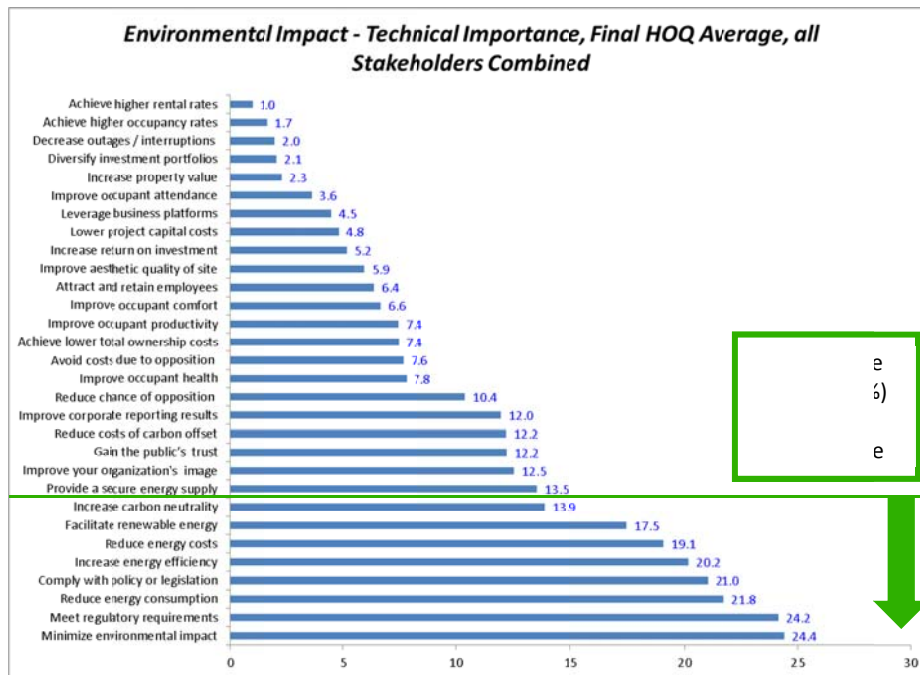
### *6.5.2 – Main Stakeholder Requirements for Each Sustainability Consideration*

Each stakeholder requirement can be described as having the ability to provide benefits with social, economic, and environmental impacts. In this section, the hierarchy of the stakeholder requirements in each of the main sustainability considerations will be explored to provide a comparison for what stakeholder requirements were most important in each category, similar to the analysis of Section 6.3. These results will provide an indication of any overlap that exists between the most important stakeholder requirement in each of the categories of social, environmental, and economic impact.

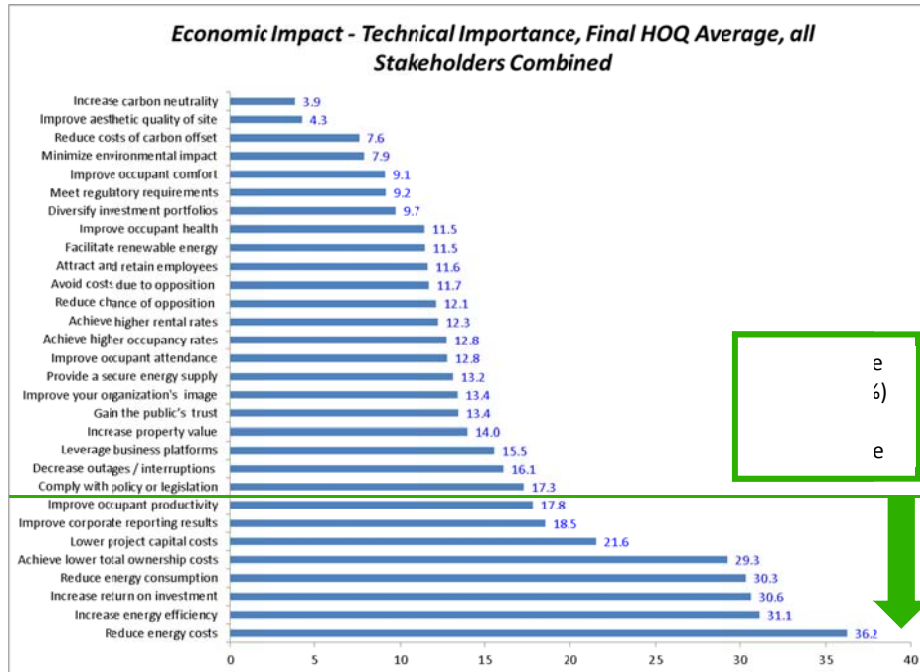
In Figure 30, Figure 31, and Figure 32 the most important requirements are identified for each sustainability consideration as being in the third quartile (upper 25%) of the technical importance results. Table 19 provides a summary of the requirements that were found to belong to the third quartile of each category. Quartile calculations are provided in the summary tables of Appendices G – I.



**Figure 30 – HOQ Technical Importance, Impact of Stakeholder Requirements on Social Considerations**



**Figure 31 – HOQ Technical Importance, Impact of Stakeholder Requirements on Environmental Considerations**



**Figure 32 – HOQ Technical Importance, Impact of Stakeholder Requirements on Economic Considerations**

**Table 19 – 3<sup>rd</sup> Quartile Comparison, Impact of Stakeholder Requirements on Sustainability Considerations**

| Requirement                    | Sustainability Considerations – 3 <sup>rd</sup> Quartile Ranking Comparison |        |             |          |
|--------------------------------|---|--------|-------------|----------|
|                                | Importance  | Social | Environment | Economic |
| Reduce energy costs            | 3   | 3      | 3           | 3        |
| Reduce energy consumption      | 3   | 3      | 3           | 3        |
| Increase energy efficiency     | 3   | 3      | 3           | 3        |
| Meet regulatory requirements   | 3   | 2      | 3           | 3        |
| Improve corporate reporting    | 2   | 3      | 1           | 3        |
| Lower TOC                      | 3   | 1      | 2           | 3        |
| Increase ROI                   | 3   | 2      | 2           | 3        |
| Improve occupant productivity  | 2   | 2      | 2           | 3        |
| Lower project capital costs    | 2   | 1      | 1           | 3        |
| Improve organization's image   | 2   | 3      | 2           | 2        |
| Comply with policy/legislation | 3   | 3      | 3           | 2        |
| Minimize environmental impact  | 2   | 3      | 3           | 1        |
| Facilitate renewable energy    | 2   | 3      | 3           | 1        |
| Increase carbon neutrality     | 1   | 2      | 3           | 1        |

The ranking results summarized in Table 19 demonstrate that the stakeholders believe the requirements to reduce energy cost, reduce energy consumption, and increase energy efficiency are all among the most important requirements in delivering positive social, environmental, and economic impacts. Section 6.3 confirmed that economic and energy savings requirements were most important to the stakeholders in their sustainable retrofit endeavors, and this section demonstrated that the stakeholders' most important requirements are perceived to have the biggest impact on economic considerations. Furthermore, the stakeholders believe that federal policy is providing the most impact on social and environmental concerns, and has slightly less impact on economic concerns. Therefore, the stakeholders do perceive that federal policy was developed with the intentions of providing social and environmental impacts over budgetary concerns.

The requirements to improve corporate reporting and improve the organization's image are perceived to have the most substantial impacts on social and economic considerations. As illustrated in Section 6.5.1, sustainable business advocates report that corporations that take measures to create transparency within their operations through corporate sustainability reporting have been able to improve their image and therefore create increased public trust that results in economic returns because people are more likely to consume that corporations products or do business with them (Singer et al. 2007; Savitz and Weber 2006; Gluch and Baumann 2003).

The stakeholders perceive that their requirements to minimize the environmental impact, facilitate renewable energy, and increase carbon neutrality have primary impacts on social and environmental considerations, and little impact on economic considerations. For example, harvesting renewable energy and increasing carbon neutrality will conserve natural resources for future generations and reduce the harmful impacts of greenhouse gases on the global

environment. Possible explanations for these items being perceived as having small economic impacts include the uncertainty in future carbon taxes and the effects of global warming (Gaterell and McEvoy 2005; Papadopoulos et al. 2002). Another possible explanation is that the stakeholders may perceive that initial investment costs and available energy efficiency levels for renewable technology are not matched by economic benefits (Scofield 2009; Prowler 2012).

The stakeholder objectives for lowering total ownership costs, increasing the return on investment, and lowering project capital costs were found to be mainly associated with having an economic impact. However, increasing profit frees up financial resources for other funding priorities that can enhance the social well-being of employees through economic stimulation, job security and profit sharing to name a few (Savitz and Weber 2006). Improving occupant productivity was only perceived as important in providing economic impacts, most likely for business profit maximization; however, productivity was found to be the number one factor in motivating employees and providing job satisfaction by a survey conducted by Amabile and Kramer (2010). Lastly, meeting regulatory requirements was found to have the most substantial impact on environmental and economic considerations (i.e. avoiding fines and a diminished reputation), and less impact on the long term social considerations that regulatory requirements are striving to preserve.

### *6.5.3 – Summary: Social, Environmental, and Economic Sustainability*

#### *Considerations*

In this section, stakeholder perceptions concerning the impact of their sustainable retrofit requirements on social, environmental, and economic considerations were evaluated. This evaluation was performed to determine the balance that exists between the sustainable retrofit

considerations and to determine what requirements are most important to the stakeholders in delivering beneficial impacts to each consideration. It was demonstrated in this case study that the stakeholders' retrofit decision was based primarily on delivering economic impacts; however, the harmony between perceptions concerning social, environmental, and economic factors is not substantially out of balance. There was overlap in perceptions concerning resulting social, environmental, and economic impacts as reinforced by the intentions of federal policy. Furthermore, the most important requirements that are perceived to provide a balance amongst social, economic, and environmental impacts were to reduce energy cost, reduce energy consumption, and increase energy efficiency. In summary, the stakeholders believe that the biggest impacts can be made by using less energy.

#### *6.6 – Limitations of the Results and Data*

The objectives of this research were developed in order to study an aspect of the sustainable retrofit decision making process for existing buildings that has not been addressed by most studies in the literature review of Chapter 2 – the important role that different building stakeholders play in determining how, why, and if retrofit measures will be implemented and the development of methodologies that enhance the interaction amongst these stakeholders. The HOQ was selected as a decision-making framework that has the ability to integrate the many stakeholders and their requirements in order to overcome the barriers to sustainable retrofits, and a HOQ model was developed to meet the research objectives. The model was applied to a case study building and its stakeholders, and an innovative way of analyzing the HOQ data was introduced to study the motivations and interactions amongst the stakeholders. The results produced in this research will assist future researchers in understanding the stakeholders' role and develop decision making models that integrate social, environmental, economic, and

technical aspects of the retrofit decision. Furthermore, the results of this research will aid the existing building community in understanding the conflict that exists in the sustainable retrofit process to overcome this barrier.

In addition to the benefits of this study, there were several limitations that must be recognized when considering the results. These limitations can be placed in the context of the methodology that was designed, the data that was collected, and the case study that was evaluated. As indicated in the literature review of Section 4.3, there is no best way to implement the HOQ, each HOQ exercise is as unique as each project in itself, and HOQ matrices produced most likely cannot be reused as templates for future projects (Ahmed et al. 2003; Mallon and Mulligan 1993). Therefore, the design of the HOQ matrices is equally important as the data obtained and great care must be taken in their design.

This research included objectives to compare different stakeholder groups and their perceptions concerning what stakeholder requirements are most important and how those requirements impact social, environmental, and economic considerations. As indicated in the results, there may not have been an equal balance in requirements that applied to each respective group of stakeholders, their requirements, or each category of sustainability consideration. For instance, there may not have been enough stakeholder requirements that were specific to the plumbing system, facilities managers, or the social implications of sustainability. For example, there were not many requirements that applied primarily to facilities managers such as maintainability, easy access, or training for any new technology that could be implemented. However, the stakeholder requirements obtained through the literature review in this research were specific to sustainable retrofits, and the example facility manager requirements are applicable to any retrofit project.

Nonetheless, an imbalance in stakeholder requirements amongst the stakeholder groups, the technical retrofit categories, and the categories of social, environmental, and economic consideration could potentially explain why owner requirements, tenant requirements, and economic considerations were the primary objectives. Conversely, this limitation in the findings of this study could validate that an imbalance does exist and that different types of stakeholders and the social, environmental, and economic aspects of sustainability are not equally weighted.

In addition, this research relied solely on qualitative data which is subjective in nature. The data obtained in this research relied on the experience, intuition, professional judgment, and decision making authority of the case study participants. The HOQ methodology was originally developed to be conducted in working group exercises in which small groups of stakeholder representatives, whom meet the prerequisite requirements for experience described in this section, can exchange information and reach a consensus (Delgado-Hernandez et al. 2007; Dikmen et al. 2005; Ahmed et al. 2003; Eldin and Hikle 2003; Yang et al. 2003; Gargione 1998). The data collection procedures that were followed in this research, as described in Section 5.3, were designed to address these requirements. However, the data was collected by means of a survey questionnaire and the consensus of each stakeholder group was reached by taking the average of each group's responses, rather than through an exchange of information between stakeholders.

To address the problem of having varying numbers of participants in each stakeholder group, an average was taken that equally accounted for each stakeholder group in the final HOQ decision. This was done in order to prevent stakeholder groups with more participants from dominating the final HOQ decision, as an objective of this research was to determine who is

driving the decision according to their requirements, not according to the size of their group. However, this method for obtaining a decision was still an average, and not a consensus.

Furthermore, the data provided by each stakeholder relied completely on their individual interpretation of the survey questions, even though the objectives of the survey were verbally presented to the stakeholders and definitions were provided for terms used in the survey. However, the HOQ is a qualitative and subjective process and so is the capital planning process as typically practiced in industry (Ahmed et al. 2003). Results and decision making methodologies produced by research applications provide great assistance in augmenting decisions and reducing the subjectivity in the process.

Lastly, the results of this research are only applicable to this case study and cannot be proven as representative of the existing building community, any stakeholder group, or federal government employees. A reasonably credible pattern of survey data was collected with 30 valid responses to meet the central limit theorem of statistics, which states sampling distributions of means are normally distributed and can be used to represent a larger population for a statistical comparison (Tabachnick and Fidell 2007). However, the 30 responses were broken up into several small groups of stakeholders and the significance of the results cannot be proven to represent any population or community. Furthermore, random sampling that is often required to associate results from a smaller sample to represent a larger population was not performed in this research. In this research judgment samples were taken to get the opinions of preselected subject matter experts in accordance with the prerequisite experience for decision making authority described earlier in this section (Berenson et al. 2009; Tabachnick and Fidell 2007).

## Chapter 7: Conclusions and Recommendations

### 7.1 – Conclusions

This research demonstrated that the HOQ is a powerful tool for translating many competing stakeholder requirements into prioritized technical focus areas for project planning and design efforts. The stakeholders in this case study were in alignment concerning their main requirements for implementing sustainable retrofits in each of the four main building systems. However, there were several inconsistencies concerning the technical importance that the different stakeholders placed on their requirements of intermediate and low importance. Nevertheless, the HOQ model that was developed through this research was able to synthesize any differences that did exist and provided consistent results that each stakeholder group agreed upon in the end. The stakeholders in this case study agreed that the focus of project resources for sustainable retrofits to the case study building should be as follows:

1. Mechanical system retrofits
2. Building envelope retrofits
3. Electrical system retrofits
4. Plumbing system retrofits

More importantly, the case study that this research was based upon demonstrated that a top-down owner commitment to sustainability works. For example, Executive Order 13423 (2007) ““Federal Leadership in High Performance and Sustainable Buildings”, strategic visions such as the White House’s (2011) “Blueprint for a Secure Energy Future”, and the Navy’s Net Zero Energy Program with a goal for 50 percent of its bases to have net zero energy consumption by 2020 (Callahan et al. 2011) have integrated stakeholder priorities in this case study. In this case study, the U.S Federal Government and U.S. Navy’s commitment to sustainability was able

to align the many competing requirements of their owner, tenant, designer, and facilities management representatives and eliminate several barriers that could potentially get in the way of efficient project decisions and results.

In general, all 5 of the main groups of stakeholders involved in this study; including the tenant, owner, facility managers, designers, and environmental compliance managers agreed without persuasion that the primary reasons for implementing sustainable retrofits in each of the mechanical, electrical, plumbing, and building envelope systems are as follows:

- Reduce energy costs
- Reduce energy consumption
- Increase energy efficiency
- Lower total ownership costs (TOC)
- Increase return on investment (ROI)
- Comply with policy or legislations
- Meet regulatory requirements

Therefore, it was determined that the stakeholder type in this U.S. Government case study does not have an effect on the sustainable retrofit decision. Furthermore, these findings reaffirm that the decision to sustainably retrofit an existing building appears to be made primarily based upon economic grounds in this case study (Entrop et al. 2010; Yudelson 2010; McKinsey and Company 2008). None of the requirements that are typically associated with the enhancing the building environment for the tenants fell among the most important requirement for initiating sustainable retrofits in the case study building, even according to the tenants. However, these soft and long term social, environmental, and economic benefits were all placed shortly after

financial concerns in the stakeholder priorities for each of the four main building systems. These secondary reasons for implementing sustainable retrofits are as follows:

- Improve occupant comfort
- Decrease outages and interruptions
- Improve occupant productivity
- Improve occupant health
- Improve occupant attendance
- Attract and retain employees

Therefore, the stakeholders in this case study perceive that decreased outages and increasing comfort are the most important tenant oriented sustainable retrofit requirements, and that the other tenant oriented requirements that result from sustainable retrofits are all secondary benefits. In other words, the stakeholders believe that if the tenants' primary needs of uninterrupted comfort are met, that they will experience fewer health concerns, less missed work days, less attrition, and improved productivity in the long run.

Furthermore, the case study stakeholder priorities indicated that the following stakeholder priorities of lower importance in their sustainable retrofit endeavors are the underlying principles behind their sustainable retrofit goals as established by the higher level policy that they are in alignment with:

1. Minimize environmental impacts
2. Facilitate renewable energy
3. Provide a secure energy supply
4. Improve corporate reporting
5. Improve the organization's image

6. Reduce the chance of opposition
7. Reduce the costs associated with opposition

Finally, it was demonstrated in this case study that the stakeholders' were aligned in their retrofit decision, and that the decision was based primarily on delivering economic impacts. However, the harmony between perceptions concerning social, environmental, and economic factors was not substantially out of balance. There was overlap in perceptions concerning the resulting social, environmental, and economic benefits as reinforced by the intentions of federal policy. Furthermore, the most important requirements that were perceived to provide a balance amongst social, economic, and environmental impacts in this case study were to reduce energy cost, reduce energy consumption, and increase energy efficiency.

In summary, the stakeholders believe that the most progress towards social, environmental, and economic sustainability can be achieved by using less energy; as energy conservation is the key to energy security and mitigating the adverse impacts of global warming (EIA 2011; Yudelson 2010). Furthermore, this case study demonstrates that the retrofit decision was primarily based on economic factors; however, social and environmental considerations are important to the case study stakeholders and on the forefront of government policy. In other words, this case study demonstrates that progress is being made towards the principles of sustainability in which "profit would meet common good" and where impacts on social, environmental, and economic considerations would be equally shared (Savitz and Weber 2006).

## *7.2 – Recommendations*

The objectives of this research were developed in order to study an aspect of the sustainable retrofit decision making process for existing buildings that has not been addressed by most studies in the literature review of Chapter 2 – the important role that different building stakeholders play in determining how, why, and if retrofit measures will be implemented and the development of methodologies that enhance the interaction amongst these stakeholders. The HOQ was selected as a decision-making framework that has the ability to integrate the many stakeholders and their requirements in order to overcome the barriers to sustainable retrofits, and a HOQ model was developed to meet the research objectives. The model was applied to a case study building and its stakeholders, and an innovative way of analyzing the HOQ data was introduced to study the motivations and interactions amongst the stakeholders.

The results produced in this research will contribute to the body of knowledge and assist future researchers in understanding the stakeholders' role in the development of decision making models that integrate social, environmental, economic, and technical aspects of the retrofit decision. Furthermore, the results of this research will aid the existing building community in understanding conflicting stakeholder requirements that exist in the sustainable retrofit process and in overcoming barriers that could obstruct efficient project decisions.

Recommendations resulting from this research have been put into the context of recommendations for existing building community stakeholders, recommendations related to this research, and recommendations for future research. This research demonstrated that the capital planning process must incorporate and integrate stakeholders that represent all aspects of operations and use throughout a building's lifecycle to increase transparency, efficiency, and cost

effectiveness. This case study also demonstrated that a top-down owner commitment to sustainability produces results that align the many stakeholders and their competing objectives.

In this research, a methodology was proposed that enhances the interaction amongst the many stakeholders and their competing requirements in order to overcome barriers in implementing sustainable retrofits. Methodologies such as the one proposed in this research are slightly less important in cultures with strong policy such as the U.S. Federal Government, and it is recommended that owners and designers incorporate methodologies such as this and whole building design approaches in the capital planning process for organizations without strong sustainable development policies (Torcellini et al. 2006).

The final results obtained through the HOQ model in this research indicated the technical focus areas for sustainable retrofit design efforts by ranking each of the mechanical, electrical, plumbing, and building envelope systems as a whole. This ranking was then compared to occupant satisfaction as a benchmark to validate the results. In this research, the occupant satisfaction survey alone would have produced the same results and provided the necessary information for design investigations. However, the objectives of this research were not make a final determination of what to focus on in the building, as the building systems must be evaluated as an interdependent system of technologies that operate together as one system in order to achieve maximum efficiencies (Torcellini et al. 2006). The objectives of this research were to develop a HOQ model and use the model to determine the hierarchy of sustainable retrofit objectives and how the different stakeholder types affect the decision.

However, future HOQ iterations based off of this model can be used to compare and select technologies in each of the four main technical retrofit categories. Furthermore, future HOQ models can incorporate the technical correlation matrix (“Roof”) that was not of value in

this broad and initial research. This matrix is used to evaluate the interdependencies of design alternatives in one category, such as the mechanical system, with other design alternatives from the mechanical, electrical, plumbing, and building envelope systems to maximize the efficiency of the entire building system as a whole.

Furthermore, the results of this research indicate that a main component of the sustainable retrofit decision is to reduce costs and increase the return on the retrofit investment. However, building owners should not necessarily choose sustainable retrofit projects based upon the return on investment alone in certain situations where existing buildings are in disrepair and in need of major retrofit to enhance their service lives. Not all decisions in the AEC industry are motivated by costs and the U.S. Navy has demonstrated that its decisions are made based on standards. Owners will often increase their budgets to pay for building features that they want, and cost is often used as the reason to eliminate building features that they can live without (Griffith et al. 2006). Therefore, sustainable retrofits without attractive returns will still support the U.S. Navy's commitment and act as research and development in the pursuit of sustainability.

Future research towards meeting the objectives of this study are also recommended for further contributions to the body of knowledge and for additional datasets that describe the perceptions of other existing building stakeholders. This research would be beneficial to a case study involving private sector stakeholders in a multi-tenant occupied commercial building where motivations, objectives, and policy are greatly different than the challenges and constraints encountered in this case study. Many of the stakeholder requirements identified in literature and many of the issues that private sector building stakeholders face were determined to be not applicable to this public sector case study. This case study research established a methodology and data analysis procedures for evaluating how the requirements of different

stakeholders affect the sustainable retrofit decision, and future research in this area can learn from the limitations of this study and produce interesting and beneficial results for the private sector.

This broad and qualitative case study research application was an initial step in understanding the primary requirements and perceptions from different types of stakeholders for initiating different types of sustainable retrofits and integrating their competing requirements. This research emphasized the critical need for a framework that studies the relationship between the social, environmental, economic, and technical aspects of the retrofit process, and identifies optimal retrofit measures that save energy, reduce GHG emissions, and deliver enhanced environments for all building stakeholders. This research studied many aspects of the retrofit decision; however, an integrated decision support framework has yet to be developed and several additional steps must be taken first.

Therefore, it is recommended that future research is conducted that investigates the available methods and technologies for each of the four retrofit components of this research in meeting the main stakeholder requirements identified in this research. Furthermore, research needs to be conducted to determine the environmental impacts of those different technologies and how this information affects the ranking of the stakeholder requirements. In addition, the economic constraints and uncertainties in regards to the environmental impacts needs to be studied to determine how these factors affect the retrofit decision and what economic valuation method is best suited for translating social and environmental benefits or constraints into economic terms.

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## **Appendix A – HOQ Importance and Relationship Survey Questionnaire**

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Dear Participant,

On behalf of the Department of Civil and Environmental Engineering at the University of Wisconsin-Madison, I am pleased to invite you to complete a survey which will be part of a research project that assesses decisions to implement sustainable retrofits in existing buildings.

This broad and qualitative survey is the first step that will help us identify the primary requirements and perceptions from different types of stakeholders for initiating different types of sustainable retrofits. The survey collects data about perceptions of sustainable retrofits in the main categories of mechanical, electrical, plumbing, and exterior systems in meeting the requirements of different individuals for a case study building, the potential renovation for Building 30 on Naval Station Great Lakes, IL. This will help identify the most important aspects to focus on in an example renovation project for Building 30 and will be an advantage to all in future decision making.

Follow-on research will then be conducted to generate a decision making tool that considers the influences of technical, environmental, and economic feasibility on the decision. The survey is intended to be completed by participants such as Building 30 tenants, owners, operators, service providers, contractors, engineers, guests, or anyone else that has an interest in the outcome of a potential renovation project.

If you have any questions, please do not hesitate to contact me at [bmbaer@wisc.edu](mailto:bmbaer@wisc.edu). Thank you for your valuable contribution to this important study.

Sincerely,

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## Sustainable Retrofit Perceptions for the Potential Renovation of Building 30

1. Please start by reading through the 3-example survey questions starting on the next page. There are 30 survey questions total that fit the same exact template of the example questions.
2. Please enter your responses in the Microsoft Excel file that accompanies the survey.
3. There are dropdown selections in each cell of the Excel file for your responses.
4. Definitions have been provided at the end of the survey for all underlined words. Please refer to the definitions so that each participant answers the survey more consistently. Hyperlinks to definitions are provided in both this word document and the excel answer sheet.
5. **IMPORTANT:** You will get the feel for the survey questions and objectives once you have read through and answered the first few questions. You should then be able to complete the rest of the survey by reading the Excel file alone, referring back to the survey text for a question's wording when necessary and to the definitions for the meaning of terms.
6. Please return your responses to [bmbaer@wisc.edu](mailto:bmbaer@wisc.edu).
7. The survey takes approximately 120 minutes. Thank you very much for your time and participation.

## 1. Reduce Energy Costs:

A potential requirement for pursuing a [sustainable retrofit](#) project in an [existing building](#) (Building 30) would be to **reduce energy costs**.

- i. How important is this requirement to you in justifying the project, in comparison to all other requirements?
  - Extremely Important
  - Very Important
  - Somewhat Important
  - Not Very Important
  - Not Important
  
- j. How strong is the ability of [mechanical system retrofits](#) in meeting the requirement to **reduce energy costs**?
  - Extremely Strong Ability
  - Very Strong Ability
  - Fairly Strong Ability
  - Weak Ability
  - No Ability
  
- k. How strong is the ability of [electrical system retrofits](#) in meeting the requirement to **reduce energy costs**?
  - Extremely Strong Ability
  - Very Strong Ability
  - Fairly Strong Ability
  - Weak Ability
  - No Ability
  
- l. How strong is the ability of [plumbing system retrofits](#) in meeting the requirement to **reduce energy costs**?
  - Extremely Strong Ability
  - Very Strong Ability
  - Fairly Strong Ability
  - Weak Ability
  - No Ability

m. How strong is the ability of [building enclosure retrofits](#) in meeting the requirement to **reduce energy costs**?

- Extremely Strong Ability
- Very Strong Ability
- Fairly Strong Ability
- Weak Ability
- No Ability

n. How strongly does the requirement to **reduce energy costs** impact [social considerations](#)?

- Extremely Strong Impact
- Very Strong Impact
- Fairly Strong Impact
- Weak Impact
- No Impact

o. How strongly does the requirement to **reduce energy costs** impact [environmental considerations](#)?

- Extremely Strong Impact
- Very Strong Impact
- Fairly Strong Impact
- Weak Impact
- No Impact

p. How strongly does the requirement to **reduce energy costs** impact [economic considerations](#)?

- Extremely Strong Impact
- Very Strong Impact
- Fairly Strong Impact
- Weak Impact
- No Impact

## 2. Increase Return on Investment:

A potential requirement for pursuing a sustainable retrofit project in an existing building (Building 30) would be to **increase the return on investment of the project**. (29 more requirements to go).

- a. How important is this requirement to you in justifying the project, in comparison to all other requirements?
  - Extremely Important
  - Very Important
  - Somewhat Important
  - Not Very Important
  - Not Important
  
- b. How strong is the ability of **mechanical system retrofits** in meeting the requirement to **increase the return on investment**?
  - Extremely Strong Ability
  - Very Strong Ability
  - Fairly Strong Ability
  - Weak Ability
  - No Ability
  
- c. How strong is the ability of **electrical system retrofits** in meeting the requirement to **increase the return on investment**?
  - Extremely Strong Ability
  - Very Strong Ability
  - Fairly Strong Ability
  - Weak Ability
  - No Ability
  
- d. How strong is the ability of **plumbing system retrofits** in meeting the requirement to **increase the return on investment**?
  - Extremely Strong Ability
  - Very Strong Ability
  - Fairly Strong Ability
  - Weak Ability
  - No Ability

- e. How strong is the ability of **Building enclosure retrofits** in meeting the requirement to **increase the return on investment**?
- Extremely Strong Ability
  - Very Strong Ability
  - Fairly Strong Ability
  - Weak Ability
  - No Ability
- f. How strongly does the requirement to **increase the return on investment** impact [social considerations](#)?
- Extremely Strong Impact
  - Very Strong Impact
  - Fairly Strong Impact
  - Weak Impact
  - No Impact
- g. How strongly does the requirement to **increase the return on investment** impact [environmental considerations](#)?
- Extremely Strong Impact
  - Very Strong Impact
  - Fairly Strong Impact
  - Weak Impact
  - No Impact
- h. How strongly does the requirement to **increase the return on investment** impact [economic considerations](#)?
- Extremely Strong Impact
  - Very Strong Impact
  - Fairly Strong Impact
  - Weak Impact
  - No Impact

### 3. Minimize Environmental Impact:

A potential requirement for pursuing a sustainable retrofit project in an existing building (Building 30) would be to **minimize the building's impact to the environment**. (28 more requirements to go)

- a. How important is this requirement to you in justifying the project, in comparison to all other requirements?
  - Extremely Important
  - Very Important
  - Somewhat Important
  - Not Very Important
  - Not Important
  
- b. How strong is the ability of mechanical system retrofits in meeting the requirement to **minimize the environmental impact**?
  - Extremely Strong Ability
  - Very Strong Ability
  - Fairly Strong Ability
  - Weak Ability
  - No Ability
  
- c. How strong is the ability of electrical system retrofits in meeting the requirement to **minimize the environmental impact**?
  - Extremely Strong Ability
  - Very Strong Ability
  - Fairly Strong Ability
  - Weak Ability
  - No Ability
  
- d. How strong is the ability of plumbing system retrofits in meeting the requirement to **minimize the environmental impact**?
  - Extremely Strong Ability
  - Very Strong Ability
  - Fairly Strong Ability
  - Weak Ability
  - No Ability

- e. How strong is the ability of **building enclosure retrofits** in meeting the requirement to **minimize the environmental impact**?
- Extremely Strong Ability
  - Very Strong Ability
  - Fairly Strong Ability
  - Weak Ability
  - No Ability
- f. How strongly does the requirement to **minimize the environmental impact**, impact [social considerations](#)?
- Extremely Strong Impact
  - Very Strong Impact
  - Fairly Strong Impact
  - Weak Impact
  - No Impact
- g. How strongly does the requirement to **minimize the environmental impact**, impact [environmental considerations](#)?
- Extremely Strong Impact
  - Very Strong Impact
  - Fairly Strong Impact
  - Weak Impact
  - No Impact
- h. How strongly does the requirement to **minimize the environmental impact**, impact [economic considerations](#)?
- Extremely Strong Impact
  - Very Strong Impact
  - Fairly Strong Impact
  - Weak Impact
  - No Impact

**DEFINITIONS:**

Building enclosure retrofits: Includes interventions, upgrades, modifications, adjustments, or replacement of enclosure, envelope, or “skin” system components such as windows, doors, insulation, roof, daylighting, or runoff control measures (Navigant Consulting 2011). [Go Back to Question 1](#)

Business Platforms: A marketing concept that includes individuals or organizations to whom products and services are aimed, or from where investment capital may originate (Yudelson 2010; Bernstein and Russo 2009). [Go Back to Question 30](#)

Carbon Neutrality: Achieving net zero carbon or other greenhouse gas emissions related to energy production, use, transportation, or industrial processes by balancing the amount of carbon released with an equivalent amount reduced, sequestered, or offset elsewhere (Goodward and Kelly 2010).

[Go Back to Question 7](#)

Carbon Offset: A reduction in emissions of carbon dioxide or greenhouse gases made in order to compensate for or to offset an emission made elsewhere. In the compliance and voluntary markets, companies, governments, or other entities buy carbon offsets in order to comply with caps on the total amount of carbon dioxide they are allowed to emit or to mitigate their own greenhouse gas emissions from transportation, electricity use, and other sources (Goodward and Kelly 2010).

[Go Back to Question 19](#)

Corporate Reporting: Reports covering environmental, social, or other non-financial sustainability issues to assist stakeholders in examining sustainability as a defining measure of corporate performance. They are often broad and voluntary reports of financial and non-financial disclosure to access an organizations investment capital, prestige, and reputation (Savitz and Weber 2006).

[Go Back to Question 28](#)

Economic constraints: Items that effect financial performance and financial resources such as sales, profit, taxes paid, debt, operating costs, return on investment, cash flow, labor costs, shareholder value, or capital (Savitz and Weber 2006). [Go Back to Question 1](#)

Electrical system retrofits: Includes interventions, upgrades, modifications, adjustments, or replacement of electrical system components such as lighting fixtures, lighting controls, or electrical circuiting and controls (Navigant Consulting 2011). [Go Back to Question 1](#)

Environmental factors, impact: Concern for the effect of your actions on the quality and supply of natural resources such as air, water, soil, ozone, energy sources, foodstuffs. Minimizing the environmental impact by preserving natural resources to support native species, maintain natural ecological processes, sustain air and water resources, and contribute to health and quality of life (Savitz and Weber 2006). [Go Back to Question 1](#)

Existing building: Any building that is more than two years old (Naval Facilities Engineering Command (NAVFAC) 2010). [Go Back to Question 1](#)

Investment Portfolios: A pool of different investments chosen generally on the basis of different risk-reward combinations with the potential for growth (www.dictionary.com /definition).

Sustainable buildings or products have become an area or category for investments and corporate performance evaluation (Savitz and Weber 2006). [Go Back to Question 29](#)

Mechanical system retrofits: Includes interventions, upgrades, modifications, adjustments, or replacement of mechanical system components such as heating ventilation and air conditioning (HVAC) recommissioning, HVAC control, HVAC system, motors and drivers, thermal distribution system, or heating hot water systems (Navigant Consulting 2011). [Go Back to Question 1](#)

Opposition: a disapproving attitude toward something (such as a construction project) and a wish to prevent it, or action taken to show disapproval of and prevent something. Opposition to a proposed construction project can come from the public or organized social, political, or environmental interest groups (Singer et. al 2007, www.bing.com/dictionary). [Go Back to Question 13](#)

Plumbing system retrofits: Includes interventions, upgrades, modifications, adjustments, or replacement of plumbing system components such as the domestic hot and cold water systems, plumbing fixtures for water and wastewater, or water recycling measures (Navigant Consulting 2011). [Go Back to Question 1](#)

Regulatory Requirements: Restrictions, licenses, or laws applicable to a product or business, imposed by government organizations such as the Occupational Safety and Health Administration, US Environmental Protection Agency, US Army Corps of Engineers, or state and local authorities (Savitz and Weber 2006). [Go Back to Question 9](#)

Renewable energy: Energy that comes from naturally replenished sources such as sunlight, wind, rain, tides, or geothermal heat. The overall function or structure of a building can be used to facilitate such energy (Executive Order 13423 2007). [Go Back to Question 17](#)

Retrofit: An intervention on the sheathing surfaces (building enclosure, envelope, or skin) or the technical systems (mechanical, electrical, or plumbing) to improve or restore their quality to optimize the intended use of the building (Rey, 2004). A building renovation includes many retrofits.

[Go Back to Question 1](#)

Return on Investment (ROI): A performance measure used to evaluate the efficiency of an investment or to compare the efficiency of a number of different investments. To calculate ROI, the benefit (return) of an investment is divided by the cost of the investment (NAVFAC 2010). [Go Back to Question 2](#)

Secure energy supply: A reliable supply of energy that meets both current needs without interruptions and the needs of future generations (Navigant consulting 2011, Yudelson 2010). [Go Back to Question 16](#)

Social factors: Acknowledging the needs and interests of other parties such as community groups, educational and religious institutions, the workforce, public, and future generations in order to reinforce the network of relationships that ties them all together. Social concerns include labor practices, community impacts, human rights, product responsibility, and human values including family life, intellectual growth, artistic expression, and moral and spiritual development (Savitz and Weber 2006). [Go Back to Question 1](#)

Stakeholder: Anyone who is affected by, or can affect, an organization (Freeman, cited in Savitz and Weber 2006).

Sustainability: Prosper financially while protecting and renewing social, environmental, and economic resources (Savitz and Weber 2006).

Sustainable development: Development that meets the needs of the present without compromising the ability of future generations to meet their own needs (Yudelson 2010).

Green building practices are included under the umbrella of sustainable development and employ multiple practices, products, and processes covering a minimum of three out of five aspects of green building – energy (efficiency, emissions), resource efficiency (water, recycled materials), improved indoor environmental quality, or responsible site management (Bernstein and Russo 2009). [Go Back to Question 1](#)

Total Ownership Costs: All costs associated with the cradle to cradle lifecycle costs of a building, including planning, design, construction, maintenance, disposal, replacement, and operating costs such as utilities and waste charges. [Go Back to Question 8](#)

## **Appendix B – HOQ Importance Data and Calculations**

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**Table 20 – Importance Rating Data: HOQ Survey Individual Participant Responses**

| Potential Stakeholder Requirements:    | Importance Rating Data |          |          |          |                   |               |               |                 |               |                 |              |                |                      |                        |                      |                      |                         |                             |                              |                             |                   |                       |               |                   |               |                   |               |               |               |                          |   |   |
|--|------------------------|----------|----------|----------|-------------------|---------------|---------------|-----------------|---------------|-----------------|--------------|----------------|----------------------|------------------------|----------------------|----------------------|-------------------------|-----------------------------|------------------------------|-----------------------------|-------------------|-----------------------|---------------|-------------------|---------------|-------------------|---------------|---------------|---------------|--------------------------|---|---|
|  | Tenant 4               | Tenant 3 | Tenant 2 | Tenant 1 | Tenant (Director) | Tenant (APWO) | Owner 1 (UEM) | Owner 2 (UEM-J) | Owner 3 (UEM) | Owner 4 (UEM-T) | Owner 5 (AM) | Owner 5 (AM-A) | Facility Mgr. 1 (CM) | Facility Mgr. 2 (CM-J) | Facility Mgr. 3 (EE) | Facility Mgr. 4 (ME) | Facility Mgr. 5 (Maint) | Facility Mgr. 6 (Maint - R) | Facility Mgr. 7 (Maint - K1) | Facility Mgr. 8 (Maint - K) | Designer (ME - B) | Designer 2 (ME - Byd) | Designer (ME) | Designer (ME - T) | Designer (PM) | Designer (PM - A) | Designer (CE) | Designer (TL) | Environmental | Environmental 2 (EV - S) |   |   |
| 1 Reduce energy costs                  | 4                      | 5        | 5        | 4        | 5                 | 5             | 5             | 5               | 5             | 5               | 5            | 5              | 5                    | 5                      | 5                    | 5                    | 5                       | 5                           | 5                            | 5                           | 5                 | 5                     | 5             | 5                 | 5             | 5                 | 5             | 5             | 5             | 5                        | 5 |   |
| 2 Increase return on investment        | 4                      | 5        | 5        | 5        | 4                 | 5             | 5             | 5               | 5             | 5               | 5            | 5              | 5                    | 5                      | 4                    | 4                    | 5                       | 5                           | 5                            | 5                           | 5                 | 5                     | 5             | 5                 | 5             | 5                 | 5             | 5             | 5             | 5                        | 5 |   |
| 3 Minimize environmental impact        | 3                      | 4        | 3        | 4        | 3                 | 4             | 3             | 4               | 3             | 3               | 3            | 3              | 4                    | 4                      | 3                    | 5                    | 4                       | 3                           | 4                            | 4                           | 3                 | 3                     | 4             | 2                 | 4             | 4                 | 4             | 3             | 5             | 4                        | 4 |   |
| 4 Improve your organization's image    | 4                      | 4        | 3        | 3        | 3                 | 2             | 3             | 3               | 3             | 3               | 5            | 3              | 3                    | 3                      | 3                    | 3                    | 3                       | 2                           | 3                            | 2                           | 2                 | 2                     | 2             | 2                 | 4             | 3                 | 2             | 3             | 3             | 3                        | 3 |   |
| 5 Improve occupant comfort             | 3                      | 4        | 4        | 5        | 5                 | 3             | 3             | 4               | 4             | 3               | 4            | 4              | 4                    | 4                      | 4                    | 4                    | 4                       | 4                           | 4                            | 3                           | 2                 | 2                     | 3             | 3                 | 4             | 4                 | 4             | 4             | 3             | 3                        | 3 |   |
| 6 Increase energy efficiency           | 4                      | 5        | 5        | 4        | 5                 | 5             | 5             | 5               | 5             | 5               | 5            | 5              | 5                    | 5                      | 5                    | 5                    | 5                       | 5                           | 5                            | 4                           | 4                 | 4                     | 3             | 3                 | 5             | 4                 | 4             | 4             | 4             | 4                        | 4 |   |
| 7 Increase carbon neutrality           | 3                      | 3        | 4        | 2        | 2                 | 1             | 2             | 2               | 1             | 3               | 3            | 2              | 2                    | 1                      | 5                    | 3                    | 3                       | 1                           | 3                            | 0                           | 1                 | 3                     | 0             | 1                 | 1             | 0                 | 3             | 3             | 2             | 2                        | 3 | 3 |
| 8 Achieve lower total ownership costs  | 4                      | 5        | 4        | 5        | 4                 | 5             | 4             | 4               | 5             | 5               | 5            | 5              | 5                    | 5                      | 5                    | 4                    | 4                       | 5                           | 4                            | 5                           | 4                 | 5                     | 4             | 5                 | 3             | 5                 | 4             | 5             | 5             | 5                        | 5 |   |
| 9 Meet regulatory requirements         | 4                      | 3        | 2        | 4        | 5                 | 4             | 5             | 3               | 5             | 4               | 5            | 5              | 5                    | 5                      | 5                    | 5                    | 5                       | 3                           | 4                            | 3                           | 4                 | 4                     | 3             | 3                 | 5             | 4                 | 4             | 5             | 5             | 4                        | 5 |   |
| 10 Comply with policy or legislation   | 4                      | 5        | 5        | 5        | 4                 | 3             | 3             | 5               | 5             | 5               | 5            | 5              | 5                    | 5                      | 5                    | 5                    | 5                       | 5                           | 5                            | 5                           | 5                 | 4                     | 4             | 3                 | 3             | 5                 | 5             | 4             | 4             | 5                        | 5 |   |
| 11 Improve aesthetic quality of site   | 2                      | 3        | 2        | 4        | 4                 | 2             | 2             | 2               | 2             | 2               | 3            | 4              | 3                    | 2                      | 2                    | 2                    | 2                       | 2                           | 3                            | 3                           | 2                 | 2                     | 2             | 1                 | 1             | 3                 | 0             | 1             | 3             | 2                        | 2 |   |
| 12 Improve occupant productivity       | 4                      | 5        | 3        | 5        | 5                 | 2             | 3             | 3               | 4             | 3               | 3            | 3              | 3                    | 3                      | 4                    | 5                    | 4                       | 4                           | 4                            | 4                           | 4                 | 3                     | 3             | 3                 | 4             | 3                 | 3             | 3             | 4             | 4                        | 4 |   |
| 13 Reduce chance of opposition         | 4                      | 2        | 2        | 3        | 3                 | 2             | 1             | 1               | 1             | 3               | 3            | 3              | 3                    | 3                      | 4                    | 4                    | 3                       | 3                           | 3                            | 4                           | 1                 | 3                     | 2             | 1                 | 1             | 0                 | 1             | 1             | 2             | 4                        | 4 |   |
| 14 Increase property value             | 4                      | 3        | 2        | 2        | 2                 | 1             | 0             | 0               | 3             | 3               | 3            | 5              | 1                    | 1                      | 2                    | 3                    | 2                       | 3                           | 3                            | 3                           | 1                 | 3                     | 2             | 1                 | 3             | 1                 | 3             | 1             | 3             | 3                        | 1 | 2 |
| 15 Reduce energy consumption           | 4                      | 5        | 5        | 5        | 4                 | 5             | 5             | 5               | 5             | 5               | 5            | 5              | 5                    | 5                      | 5                    | 5                    | 5                       | 5                           | 5                            | 5                           | 5                 | 3                     | 4             | 4                 | 3             | 5                 | 4             | 3             | 5             | 4                        | 4 |   |
| 16 Provide a secure energy supply      | 3                      | 4        | 4        | 3        | 5                 | 4             | 5             | 5               | 2             | 3               | 2            | 5              | 5                    | 5                      | 2                    | 3                    | 3                       | 2                           | 4                            | 3                           | 3                 | 3                     | 3             | 2                 | 4             | 0                 | 2             | 2             | 4             | 4                        | 4 |   |
| 17 Facilitate renewable energy         | 4                      | 4        | 4        | 2        | 2                 | 3             | 3             | 2               | 2             | 3               | 2            | 3              | 4                    | 4                      | 5                    | 2                    | 3                       | 2                           | 2                            | 2                           | 2                 | 3                     | 3             | 2                 | 2             | 4                 | 2             | 4             | 4             | 4                        | 3 |   |
| 18 Lower project capital costs         | 3                      | 0        | 0        | 4        | 5                 | 4             | 4             | 4               | 4             | 4               | 4            | 5              | 0                    | 4                      | 3                    | 3                    | 4                       | 0                           | 4                            | 4                           | 4                 | 4                     | 4             | 4                 | 0             | 0                 | 4             | 5             | 4             | 4                        | 4 |   |
| 19 Reduce costs of carbon offset       | 3                      | 4        | 3        | 3        | 4                 | 1             | 1             | 2               | 2             | 2               | 2            | 2              | 2                    | 2                      | 5                    | 2                    | 2                       | 2                           | 3                            | 4                           | 1                 | 1                     | 1             | 1                 | 4             | 2                 | 1             | 2             | 1             | 1                        | 1 |   |
| 20 Achieve higher rental rates         | 4                      | 3        | 2        | 1        | 1                 | 1             | 0             | 0               | 3             | 3               | 1            | 4              | 1                    | 0                      | 3                    | 2                    | 1                       | 1                           | 2                            | 2                           | 1                 | 3                     | 3             | 1                 | 3             | 1                 | 2             | 2             | 3             | 4                        | 4 |   |
| 21 Achieve higher occupancy rates      | 4                      | 4        | 3        | 1        | 1                 | 1             | 3             | 2               | 2             | 3               | 5            | 1              | 0                    | 3                      | 3                    | 2                    | 2                       | 2                           | 2                            | 2                           | 1                 | 3                     | 2             | 1                 | 2             | 1                 | 2             | 1             | 2             | 3                        | 4 |   |
| 22 Avoid costs due to opposition       | 4                      | 2        | 3        | 2        | 4                 | 2             | 1             | 1               | 2             | 3               | 3            | 3              | 3                    | 3                      | 4                    | 4                    | 3                       | 3                           | 3                            | 3                           | 3                 | 3                     | 3             | 1                 | 1             | 0                 | 2             | 2             | 3             | 4                        | 4 |   |
| 23 Gain the public's trust             | 4                      | 4        | 4        | 4        | 4                 | 0             | 3             | 3               | 3             | 3               | 3            | 5              | 3                    | 5                      | 3                    | 5                    | 4                       | 2                           | 3                            | 3                           | 2                 | 2                     | 3             | 3                 | 4             | 0                 | 3             | 3             | 4             | 4                        | 4 |   |
| 24 Decrease outages/ interruptions     | 4                      | 4        | 5        | 5        | 5                 | 4             | 4             | 4               | 3             | 4               | 3            | 3              | 5                    | 5                      | 3                    | 4                    | 5                       | 4                           | 3                            | 3                           | 2                 | 2                     | 3             | 3                 | 4             | 0                 | 3             | 4             | 4             | 4                        | 4 |   |
| 25 Attract and retain employees        | 4                      | 4        | 4        | 3        | 3                 | 1             | 3             | 5               | 3             | 4               | 4            | 4              | 4                    | 4                      | 5                    | 4                    | 4                       | 2                           | 3                            | 3                           | 2                 | 2                     | 3             | 2                 | 3             | 4                 | 3             | 2             | 2             | 1                        | 1 |   |
| 26 Improve occupant attendance         | 4                      | 5        | 4        | 5        | 5                 | 2             | 2             | 2               | 3             | 3               | 4            | 3              | 2                    | 2                      | 5                    | 2                    | 2                       | 3                           | 3                            | 2                           | 2                 | 2                     | 2             | 2                 | 3             | 2                 | 3             | 3             | 1             | 1                        | 1 |   |
| 27 Improve occupant health             | 4                      | 4        | 4        | 5        | 5                 | 4             | 3             | 3               | 2             | 4               | 4            | 3              | 4                    | 4                      | 2                    | 5                    | 2                       | 3                           | 3                            | 3                           | 3                 | 3                     | 3             | 3                 | 4             | 4                 | 3             | 2             | 3             | 3                        | 3 |   |
| 28 Improve corporate reporting results | 3                      | 5        | 5        | 4        | 3                 | 4             | 4             | 1               | 4             | 2               | 4            | 4              | 4                    | 4                      | 2                    | 4                    | 5                       | 3                           | 3                            | 3                           | 2                 | 2                     | 4             | 3                 | 5             | 3                 | 4             | 3             | 5             | 3                        | 5 |   |
| 29 Diversify investment portfolios     | 2                      | 3        | 2        | 1        | 1                 | 1             | 2             | 1               | 1             | 2               | 3            | 0              | 0                    | 2                      | 4                    | 2                    | 4                       | 2                           | 4                            | 4                           | 2                 | 2                     | 1             | 1                 | 3             | 0                 | 1             | 1             | 1             | 1                        | 3 |   |
| 30 Leverage business platforms         | 4                      | 5        | 5        | 4        | 1                 | 4             | 1             | 1               | 2             | 4               | 3            | 2              | 4                    | 4                      | 3                    | 4                    | 3                       | 4                           | 4                            | 4                           | 4                 | 4                     | 2             | 4                 | 1             | 5                 | 1             | 1             | 1             | 1                        | 4 | 3 |

**Table 21 – HOQ Importance Rating Summary and Data Analysis Calculations**

| Potential Stakeholder Requirements: |                                     | Summary of Importance Ratings |           |          |            |           |          |               |           |          |            |           |          |              |           |          |               |           |          |
|-------------------------------------|-------------------------------------|-------------------------------|-----------|----------|------------|-----------|----------|---------------|-----------|----------|------------|-----------|----------|--------------|-----------|----------|---------------|-----------|----------|
|                                     |                                     | Tenant                        |           |          | Owner      |           |          | Facility Mgr. |           |          | Designers  |           |          | Environmntl. |           |          | Weighted Avg. |           |          |
|                                     |                                     | Average                       | Std. Dev. | Variance | Average    | Std. Dev. | Variance | Average       | Std. Dev. | Variance | Average    | Std. Dev. | Variance | Average      | Std. Dev. | Variance | Average       | Std. Dev. | Variance |
| 1                                   | Reduce energy costs                 | 4.7                           | 0.5       | 0.2      | 5          | 0         | 0        | 4.9           | 0.3       | 0.1      | 5          | 0         | 0        | 5            | 0         | 0        | 4.91          | 0.13      | 0.02     |
| 2                                   | Increase return on investment       | 4.7                           | 0.5       | 0.2      | 5          | 0         | 0        | 4.8           | 0.4       | 0.2      | 4.7        | 0.5       | 0.2      | 4            | 0         | 0        | 4.63          | 0.33      | 0.11     |
| 3                                   | Minimize environmental impact       | 3.5                           | 0.5       | 0.3      | 3.3        | 0.5       | 0.2      | 3.9           | 0.6       | 0.4      | 3.3        | 0.7       | 0.5      | 4.5          | 0.5       | 0.3      | 3.7           | 0.45      | 0.2      |
| 4                                   | Improve your organization's image   | 3.2                           | 0.7       | 0.5      | 3.7        | 0.9       | 0.9      | 3.1           | 0.8       | 0.6      | 2.4        | 0.7       | 0.5      | 3            | 0         | 0        | 3.08          | 0.4       | 0.16     |
| 5                                   | Improve occupant comfort            | 4                             | 0.8       | 0.7      | 3.7        | 0.5       | 0.2      | 3.8           | 0.4       | 0.2      | 3.1        | 0.8       | 0.7      | 3            | 0         | 0        | 3.51          | 0.38      | 0.14     |
| 6                                   | Increase energy efficiency          | 4.7                           | 0.5       | 0.2      | 5          | 0         | 0        | 4.9           | 0.3       | 0.1      | 3.9        | 0.6       | 0.4      | 4            | 0         | 0        | 4.48          | 0.46      | 0.22     |
| 7                                   | Increase carbon neutrality          | 2.5                           | 1         | 0.9      | 2          | 0.8       | 0.7      | 2.5           | 1.2       | 1.5      | 1.3        | 1         | 1.1      | 3            | 0         | 0        | 2.26          | 0.58      | 0.34     |
| 8                                   | Achieve lower total ownership costs | 4.5                           | 0.5       | 0.3      | 4.5        | 0.5       | 0.3      | 4.5           | 0.5       | 0.3      | 4.6        | 0.7       | 0.5      | 5            | 0         | 0        | 4.61          | 0.19      | 0.04     |
| 9                                   | Meet regulatory requirements        | 3.7                           | 0.9       | 0.9      | 4.2        | 0.9       | 0.8      | 4.5           | 0.7       | 0.5      | 3.6        | 0.5       | 0.2      | 5            | 0         | 0        | 4.18          | 0.53      | 0.28     |
| 10                                  | Comply with policy or legislation   | 4.7                           | 0.5       | 0.2      | 4.3        | 0.9       | 0.9      | 5             | 0         | 0        | 3.9        | 0.6       | 0.4      | 5            | 0         | 0        | 4.57          | 0.43      | 0.19     |
| 11                                  | Improve aesthetic quality of site   | 2.8                           | 0.9       | 0.8      | 2.5        | 0.8       | 0.6      | 2.4           | 0.5       | 0.2      | 1.9        | 0.8       | 0.7      | 2            | 0         | 0        | 2.31          | 0.35      | 0.12     |
| 12                                  | Improve occupant productivity       | 4                             | 1.2       | 1.3      | 3.3        | 0.5       | 0.2      | 3.9           | 0.6       | 0.4      | 3.1        | 0.3       | 0.1      | 4            | 0         | 0        | 3.67          | 0.36      | 0.13     |
| 13                                  | Reduce chance of opposition         | 2.7                           | 0.7       | 0.6      | 2          | 1         | 1        | 3.4           | 0.5       | 0.2      | 1.6        | 0.7       | 0.5      | 4            | 0         | 0        | 2.72          | 0.88      | 0.78     |
| 14                                  | Increase property value             | 2.3                           | 0.9       | 0.9      | 2.3        | 1.8       | 3.2      | 2.3           | 0.8       | 0.7      | 2.3        | 0.9       | 0.8      | 1.5          | 0.5       | 0.3      | 2.14          | 0.32      | 0.1      |
| 15                                  | Reduce energy consumption           | 4.7                           | 0.5       | 0.2      | 5          | 0         | 0        | 5             | 0         | 0        | 3.9        | 0.8       | 0.7      | 4            | 0         | 0        | 4.5           | 0.49      | 0.24     |
| 16                                  | Provide a secure energy supply      | 3.8                           | 0.7       | 0.5      | 3.2        | 1.3       | 1.8      | 3.4           | 1.1       | 1.2      | 2.6        | 0.7       | 0.5      | 4            | 0         | 0        | 3.39          | 0.51      | 0.26     |
| 17                                  | Facilitate renewable energy         | 3.2                           | 0.9       | 0.8      | 2.5        | 0.5       | 0.3      | 3.4           | 1.2       | 1.5      | 3.1        | 0.8       | 0.7      | 3.5          | 0.5       | 0.3      | 3.14          | 0.34      | 0.12     |
| 18                                  | Lower project capital costs         | 2.7                           | 2         | 3.9      | 4.2        | 0.4       | 0.1      | 2.6           | 1.6       | 2.5      | 3.6        | 1.5       | 2.2      | 4            | 0         | 0        | 3.41          | 0.65      | 0.42     |
| 19                                  | Reduce costs of carbon offset       | 3                             | 1         | 1        | 1.7        | 0.5       | 0.2      | 2.6           | 1.2       | 1.5      | 1.6        | 1         | 1.1      | 1            | 0         | 0        | 1.97          | 0.73      | 0.54     |
| 20                                  | Achieve higher rental rates         | 2                             | 1.2       | 1.3      | 1.8        | 1.6       | 2.5      | 1.5           | 0.9       | 0.8      | 2.1        | 0.8       | 0.7      | 3.5          | 0.5       | 0.3      | 2.2           | 0.69      | 0.47     |
| 21                                  | Achieve higher occupancy rates      | 2.3                           | 1.4       | 1.9      | 3          | 1         | 1        | 1.9           | 0.9       | 0.9      | 1.9        | 0.6       | 0.4      | 3.5          | 0.5       | 0.3      | 2.51          | 0.65      | 0.42     |
| 22                                  | Avoid costs due to opposition       | 2.8                           | 0.9       | 0.8      | 2          | 0.8       | 0.7      | 3.3           | 0.4       | 0.2      | 1.7        | 0.7       | 0.5      | 3.5          | 0.5       | 0.3      | 2.66          | 0.69      | 0.48     |
| 23                                  | Gain the public's trust             | 3.3                           | 1.5       | 2.2      | 3          | 0         | 0        | 3.8           | 1.1       | 1.2      | 2.9        | 0.6       | 0.4      | 4            | 0         | 0        | 3.39          | 0.43      | 0.19     |
| 24                                  | Decrease outages / interruptions    | 4.5                           | 0.5       | 0.3      | 3.5        | 0.5       | 0.3      | 4             | 0.9       | 0.8      | 3          | 0.8       | 0.6      | 4            | 0         | 0        | 3.8           | 0.51      | 0.26     |
| 25                                  | Attract and retain employees        | 3.2                           | 1.1       | 1.1      | 4          | 0.8       | 0.7      | 3.9           | 0.9       | 0.9      | 2.6        | 0.7       | 0.5      | 1            | 0         | 0        | 2.92          | 1.09      | 1.19     |
| 26                                  | Improve occupant attendance         | 4.2                           | 1.1       | 1.1      | 3          | 0.8       | 0.7      | 3.1           | 1.2       | 1.4      | 2.4        | 0.5       | 0.2      | 1            | 0         | 0        | 2.74          | 1.04      | 1.08     |
| 27                                  | Improve occupant health             | 4.3                           | 0.5       | 0.2      | 3          | 0.8       | 0.7      | 3.1           | 0.9       | 0.9      | 3          | 0.5       | 0.3      | 3            | 0         | 0        | 3.29          | 0.52      | 0.27     |
| 28                                  | Improve corporate reporting results | 4                             | 0.8       | 0.7      | 3.2        | 1.2       | 1.5      | 3.5           | 0.9       | 0.8      | 3.3        | 1         | 1.1      | 5            | 0         | 0        | 3.79          | 0.67      | 0.45     |
| 29                                  | Diversify investment portfolios     | 1.7                           | 0.7       | 0.6      | 2          | 0.8       | 0.7      | 2.3           | 1.6       | 2.4      | 1.6        | 0.7       | 0.5      | 2            | 1         | 1        | 1.9           | 0.25      | 0.06     |
| 30                                  | Leverage business platforms         | 3.8                           | 1.3       | 1.8      | 2.2        | 1.1       | 1.1      | 3.4           | 0.7       | 0.5      | 2.6        | 1.6       | 2.5      | 3.5          | 0.5       | 0.3      | 3.09          | 0.62      | 0.38     |
| S                                   | Minimum                             | 1.7                           |           |          | 1.7        |           |          | 1.5           |           |          | 1.3        |           |          | 1.0          |           |          | 1.9           |           |          |
| T                                   | 1st Quartile (lower 25%)            | 2.8                           |           |          | 2.4        |           |          | 2.8           |           |          | 2.2        |           |          | 3.0          |           |          | 2.6           |           |          |
| A                                   | <b>Median</b>                       | <b>3.6</b>                    |           |          | <b>3.2</b> |           |          | <b>3.4</b>    |           |          | <b>2.9</b> |           |          | <b>3.8</b>   |           |          | <b>3.3</b>    |           |          |
| T                                   | 3rd Quartile (upper 25%)            | 4.3                           |           |          | 4.1        |           |          | 4.0           |           |          | 3.5        |           |          | 4.0          |           |          | 3.9           |           |          |
| S                                   | Maximum                             | 4.7                           |           |          | 5.0        |           |          | 5.0           |           |          | 5.0        |           |          | 5.0          |           |          | 4.9           |           |          |

**Table 22 – Pooled Variance t-Test for Two Independent Populations: Tenant and Owner**

| Pooled Variance t-Test Results: Owner vs. Tenant |        |       |          |        |       |           |       |            |          |
|--|--------|-------|----------|--------|-------|-----------|-------|------------|----------|
| Mean - O   | SD - O | n - O | Mean - T | SD - T | n - T | Pooled SD | t_0   | Critical t | Sig.?    |
| 4.67   | 0.52   | 6.00  | 5.00     | 0.00   | 6.00  | 0.37      | -1.58 | 2.23       | not sig. |
| 4.67   | 0.52   | 6.00  | 5.00     | 0.00   | 6.00  | 0.37      | -1.58 | 2.23       | not sig. |
| 3.50   | 0.55   | 6.00  | 3.33     | 0.52   | 6.00  | 0.53      | 0.54  | 2.23       | not sig. |
| 3.17   | 0.75   | 6.00  | 3.67     | 1.03   | 6.00  | 0.90      | -0.96 | 2.23       | not sig. |
| 4.00   | 0.89   | 6.00  | 3.67     | 0.52   | 6.00  | 0.73      | 0.79  | 2.23       | not sig. |
| 4.67   | 0.52   | 6.00  | 5.00     | 0.00   | 6.00  | 0.37      | -1.58 | 2.23       | not sig. |
| 2.50   | 1.05   | 6.00  | 2.00     | 0.89   | 6.00  | 0.97      | 0.89  | 2.23       | not sig. |
| 4.50   | 0.55   | 6.00  | 4.50     | 0.55   | 6.00  | 0.55      | 0.00  | 2.23       | not sig. |
| 3.67   | 1.03   | 6.00  | 4.17     | 0.98   | 6.00  | 1.01      | -0.86 | 2.23       | not sig. |
| 4.67   | 0.52   | 6.00  | 4.33     | 1.03   | 6.00  | 0.82      | 0.71  | 2.23       | not sig. |
| 2.83   | 0.98   | 6.00  | 2.50     | 0.84   | 6.00  | 0.91      | 0.63  | 2.23       | not sig. |
| 4.00   | 1.26   | 6.00  | 3.33     | 0.52   | 6.00  | 0.97      | 1.20  | 2.23       | not sig. |
| 2.67   | 0.82   | 6.00  | 2.00     | 1.10   | 6.00  | 0.97      | 1.20  | 2.23       | not sig. |
| 2.33   | 1.03   | 6.00  | 2.33     | 1.97   | 6.00  | 1.57      | 0.00  | 2.23       | not sig. |
| 4.67   | 0.52   | 6.00  | 5.00     | 0.00   | 6.00  | 0.37      | -1.58 | 2.23       | not sig. |
| 3.83   | 0.75   | 6.00  | 3.17     | 1.47   | 6.00  | 1.17      | 0.99  | 2.23       | not sig. |
| 3.17   | 0.98   | 6.00  | 2.50     | 0.55   | 6.00  | 0.80      | 1.45  | 2.23       | not sig. |
| 2.67   | 2.16   | 6.00  | 4.17     | 0.41   | 6.00  | 1.55      | -1.67 | 2.23       | not sig. |
| 3.00   | 1.10   | 6.00  | 1.67     | 0.52   | 6.00  | 0.86      | 2.70  | 2.23       | sig.     |
| 2.00   | 1.26   | 6.00  | 1.83     | 1.72   | 6.00  | 1.51      | 0.19  | 2.23       | not sig. |
| 2.33   | 1.51   | 6.00  | 3.00     | 1.10   | 6.00  | 1.32      | -0.88 | 2.23       | not sig. |
| 2.83   | 0.98   | 6.00  | 2.00     | 0.89   | 6.00  | 0.94      | 1.54  | 2.23       | not sig. |
| 3.33   | 1.63   | 6.00  | 3.00     | 0.00   | 6.00  | 1.15      | 0.50  | 2.23       | not sig. |
| 4.50   | 0.55   | 6.00  | 3.50     | 0.55   | 6.00  | 0.55      | 3.16  | 2.23       | sig.     |
| 3.17   | 1.17   | 6.00  | 4.00     | 0.89   | 6.00  | 1.04      | -1.39 | 2.23       | not sig. |
| 4.17   | 1.17   | 6.00  | 3.00     | 0.89   | 6.00  | 1.04      | 1.94  | 2.23       | not sig. |
| 4.33   | 0.52   | 6.00  | 3.00     | 0.89   | 6.00  | 0.73      | 3.16  | 2.23       | sig.     |
| 4.00   | 0.89   | 6.00  | 3.17     | 1.33   | 6.00  | 1.13      | 1.27  | 2.23       | not sig. |
| 1.67   | 0.82   | 6.00  | 2.00     | 0.89   | 6.00  | 0.86      | -0.67 | 2.23       | not sig. |
| 3.83   | 1.47   | 6.00  | 2.17     | 1.17   | 6.00  | 1.33      | 2.17  | 2.23       | not sig. |

**Table 23 – Pooled Variance t-Test Results for Two Independent Populations:  
Facility Managers and Designers**

| Pooled Variance t-Test Results: Facility Manager vs. Designer |       |      |        |      |      |           |       |            |          |
|---|-------|------|--------|------|------|-----------|-------|------------|----------|
| Mean FM   | SD FM | n FM | Mean D | SD D | n D  | Pooled SD | t_0   | Critical t | Sig.?    |
| 5.00  | 0.00  | 8.00 | 4.00   | 0.76 | 8.00 | 0.53      | 3.74  | 2.14       | sig.     |
| 5.00  | 0.00  | 8.00 | 3.88   | 0.83 | 8.00 | 0.59      | 3.81  | 2.14       | sig.     |
| 4.88  | 0.35  | 8.00 | 4.75   | 0.71 | 8.00 | 0.56      | 0.45  | 2.14       | not sig. |
| 4.88  | 0.35  | 8.00 | 3.88   | 0.64 | 8.00 | 0.52      | 3.86  | 2.14       | sig.     |
| 4.75  | 0.46  | 8.00 | 4.63   | 0.52 | 8.00 | 0.49      | 0.51  | 2.14       | not sig. |
| 4.50  | 0.53  | 8.00 | 4.50   | 0.76 | 8.00 | 0.65      | 0.00  | 2.14       | not sig. |
| 4.50  | 0.76  | 8.00 | 3.75   | 0.71 | 8.00 | 0.73      | 2.05  | 2.14       | not sig. |
| 4.00  | 0.93  | 8.00 | 2.63   | 1.30 | 8.00 | 1.13      | 2.43  | 2.14       | sig.     |
| 3.88  | 0.64  | 8.00 | 3.38   | 0.74 | 8.00 | 0.69      | 1.44  | 2.14       | not sig. |
| 3.88  | 0.64  | 8.00 | 3.13   | 0.35 | 8.00 | 0.52      | 2.90  | 2.14       | sig.     |
| 3.88  | 0.99  | 8.00 | 2.63   | 0.74 | 8.00 | 0.88      | 2.85  | 2.14       | sig.     |
| 3.75  | 0.46  | 8.00 | 3.25   | 0.89 | 8.00 | 0.71      | 1.41  | 2.14       | not sig. |
| 3.75  | 1.16  | 8.00 | 2.50   | 1.20 | 8.00 | 1.18      | 2.12  | 2.14       | not sig. |
| 3.50  | 0.93  | 8.00 | 3.25   | 1.04 | 8.00 | 0.98      | 0.51  | 2.14       | not sig. |
| 3.38  | 0.52  | 8.00 | 1.38   | 0.92 | 8.00 | 0.74      | 5.38  | 2.14       | sig.     |
| 3.38  | 1.19  | 8.00 | 2.25   | 1.16 | 8.00 | 1.18      | 1.91  | 2.14       | not sig. |
| 3.38  | 1.30  | 8.00 | 3.00   | 0.93 | 8.00 | 1.13      | 0.66  | 2.14       | not sig. |
| 3.38  | 0.74  | 8.00 | 2.38   | 1.69 | 8.00 | 1.30      | 1.54  | 2.14       | not sig. |
| 3.25  | 0.46  | 8.00 | 1.50   | 0.93 | 8.00 | 0.73      | 4.78  | 2.14       | sig.     |
| 3.13  | 0.83  | 8.00 | 2.50   | 0.76 | 8.00 | 0.80      | 1.57  | 2.14       | not sig. |
| 3.13  | 1.25  | 8.00 | 2.38   | 0.52 | 8.00 | 0.95      | 1.57  | 2.14       | not sig. |
| 3.13  | 0.99  | 8.00 | 3.13   | 0.64 | 8.00 | 0.83      | 0.00  | 2.14       | not sig. |
| 2.63  | 1.69  | 8.00 | 3.13   | 1.96 | 8.00 | 1.83      | -0.55 | 2.14       | not sig. |
| 2.63  | 1.30  | 8.00 | 1.63   | 1.06 | 8.00 | 1.19      | 1.68  | 2.14       | not sig. |
| 2.50  | 1.31  | 8.00 | 1.50   | 1.20 | 8.00 | 1.25      | 1.60  | 2.14       | not sig. |
| 2.38  | 0.52  | 8.00 | 1.63   | 1.06 | 8.00 | 0.83      | 1.80  | 2.14       | not sig. |
| 2.25  | 0.89  | 8.00 | 2.13   | 0.99 | 8.00 | 0.94      | 0.27  | 2.14       | not sig. |
| 2.25  | 1.67  | 8.00 | 1.38   | 0.92 | 8.00 | 1.35      | 1.30  | 2.14       | not sig. |
| 1.88  | 0.99  | 8.00 | 1.75   | 0.71 | 8.00 | 0.86      | 0.29  | 2.14       | not sig. |
| 1.50  | 0.93  | 8.00 | 2.00   | 0.93 | 8.00 | 0.93      | -1.08 | 2.14       | not sig. |

**Appendix C – HOQ Mechanical System Retrofit Relationship Data, Technical Importance Calculations, and Data Analysis Calculations**

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**Table 25 – Mechanical System Technical Importance Calculations: Results for each Individual Participant**

| Potential Stakeholder Requirements: |                                     | Mechanical System Retrofit - Summary of Technical Importance |          |          |          |                   |               |               |                 |               |                 |              |                |                      |                        |                      |                      |                         |                             |                              |                             |                   |                       |               |                 |               |               |               |               |                          |    |
|-------------------------------------|-------------------------------------|--|----------|----------|----------|-------------------|---------------|---------------|-----------------|---------------|-----------------|--------------|----------------|----------------------|------------------------|----------------------|----------------------|-------------------------|-----------------------------|------------------------------|-----------------------------|-------------------|-----------------------|---------------|-----------------|---------------|---------------|---------------|---------------|--------------------------|----|
|                                     |                                     | Tenant 4   | Tenant 3 | Tenant 2 | Tenant 1 | Tenant (Director) | Tenant (APWO) | Owner 1 (UEM) | Owner 2 (UEM-J) | Owner 3 (UEM) | Owner 4 (UEM-T) | Owner 5 (AM) | Owner 5 (AM-A) | Facility Mgr. 1 (CM) | Facility Mgr. 2 (CM-J) | Facility Mgr. 3 (EE) | Facility Mgr. 4 (ME) | Facility Mgr. 5 (Maint) | Facility Mgr. 6 (Maint - R) | Facility Mgr. 7 (Maint - K1) | Facility Mgr. 8 (Maint - K) | Designer (ME - B) | Designer 2 (ME - Byd) | Designer (ME) | Designer (ME-T) | Designer (PM) | Designer (CE) | Designer (TI) | Environmental | Environmental 2 (EV - S) |    |
| 1                                   | Reduce energy costs                 | 20   | 45       | 25       | 20       | 25                | 15            | 15            | 25              | 25            | 45              | 45           | 25             | 25                   | 25                     | 25                   | 25                   | 25                      | 25                          | 25                           | 25                          | 25                | 45                    | 45            | 45              | 45            | 45            | 45            | 25            | 25                       | 25 |
| 2                                   | Increase return on investment       | 20   | 45       | 25       | 25       | 20                | 25            | 5             | 5               | 25            | 45              | 45           | 25             | 20                   | 20                     | 20                   | 20                   | 20                      | 20                          | 20                           | 20                          | 20                | 45                    | 45            | 45              | 45            | 45            | 45            | 20            | 20                       | 20 |
| 3                                   | Minimize environmental impact       | 9  | 36       | 15       | 20       | 9                 | 12            | 9             | 20              | 15            | 9               | 9            | 20             | 20                   | 15                     | 25                   | 20                   | 20                      | 20                          | 20                           | 20                          | 3                 | 15                    | 20            | 2               | 36            | 20            | 15            | 25            | 20                       |    |
| 4                                   | Improve your organization's image   | 4  | 12       | 9        | 9        | 2                 | 3             | 3             | 3               | 3             | 5               | 5            | 3              | 3                    | 3                      | 3                    | 15                   | 3                       | 3                           | 2                            | 9                           | 2                 | 6                     | 6             | 2               | 12            | 2             | 3             | 3             | 3                        |    |
| 5                                   | Improve occupant comfort            | 15   | 12       | 36       | 45       | 45                | 15            | 15            | 36              | 36            | 15              | 36           | 36             | 36                   | 27                     | 20                   | 36                   | 20                      | 36                          | 27                           | 18                          | 18                | 27                    | 27            | 12              | 36            | 36            | 15            | 15            | 15                       |    |
| 6                                   | Increase energy efficiency          | 20   | 25       | 45       | 45       | 20                | 25            | 15            | 15              | 25            | 45              | 45           | 45             | 45                   | 45                     | 45                   | 45                   | 45                      | 45                          | 45                           | 45                          | 36                | 36                    | 27            | 25              | 36            | 36            | 20            | 20            | 20                       |    |
| 7                                   | Increase carbon neutrality          | 3  | 15       | 36       | 6        | 2                 | 1             | 6             | 5               | 27            | 27              | 6            | 6              | 5                    | 25                     | 15                   | 15                   | 3                       | 27                          | 0                            | 5                           | 5                 | 0                     | 15            | 2               | 10            | 15            | 15            | 15            | 15                       |    |
| 8                                   | Achieve lower total ownership costs | 20   | 45       | 20       | 45       | 15                | 12            | 25            | 20              | 45            | 45              | 45           | 45             | 45                   | 45                     | 25                   | 20                   | 20                      | 25                          | 36                           | 15                          | 20                | 25                    | 9             | 45              | 45            | 45            | 25            | 25            | 25                       |    |
| 9                                   | Meet regulatory requirements        | 20   | 9        | 6        | 4        | 5                 | 20            | 5             | 3               | 15            | 25              | 12           | 25             | 12                   | 25                     | 12                   | 25                   | 3                       | 12                          | 3                            | 12                          | 12                | 3                     | 9             | 0               | 0             | 25            | 25            | 25            | 25                       |    |
| 10                                  | Comply with policy or legislation   | 20   | 45       | 45       | 25       | 15                | 20            | 15            | 15              | 25            | 25              | 25           | 25             | 25                   | 15                     | 25                   | 45                   | 25                      | 15                          | 25                           | 25                          | 4                 | 20                    | 15            | 3               | 45            | 4             | 20            | 25            | 25                       |    |
| 11                                  | Improve aesthetic quality of site   | 0  | 0        | 0        | 0        | 2                 | 2             | 0             | 0               | 2             | 0               | 0            | 0              | 2                    | 2                      | 2                    | 2                    | 2                       | 2                           | 0                            | 3                           | 6                 | 6                     | 0             | 0               | 1             | 3             | 0             | 0             | 0                        |    |
| 12                                  | Improve occupant productivity       | 20   | 25       | 15       | 25       | 45                | 6             | 27            | 27              | 12            | 9               | 9            | 9              | 27                   | 12                     | 45                   | 20                   | 12                      | 12                          | 36                           | 9                           | 3                 | 3                     | 20            | 9               | 9             | 4             | 4             | 4             | 4                        |    |
| 13                                  | Reduce chance of opposition         | 20   | 2        | 0        | 9        | 9                 | 2             | 0             | 0               | 3             | 9               | 3            | 9              | 9                    | 12                     | 12                   | 3                    | 3                       | 9                           | 12                           | 0                           | 3                 | 2                     | 0             | 1               | 0             | 0             | 12            | 12            | 12                       |    |
| 14                                  | Increase property value             | 12   | 9        | 6        | 6        | 18                | 1             | 0             | 0               | 3             | 9               | 25           | 3              | 3                    | 6                      | 9                    | 6                    | 9                       | 3                           | 27                           | 1                           | 9                 | 6                     | 1             | 9               | 9             | 9             | 3             | 6             | 6                        |    |
| 15                                  | Reduce energy consumption           | 20   | 45       | 45       | 45       | 20                | 25            | 25            | 25              | 25            | 45              | 45           | 45             | 45                   | 45                     | 45                   | 45                   | 45                      | 25                          | 25                           | 27                          | 36                | 36                    | 27            | 45              | 27            | 45            | 20            | 20            |                          |    |
| 16                                  | Provide a secure energy supply      | 15   | 20       | 20       | 15       | 25                | 20            | 5             | 5               | 2             | 15              | 10           | 0              | 2                    | 3                      | 9                    | 6                    | 20                      | 15                          | 15                           | 15                          | 15                | 0                     | 20            | 0               | 2             | 20            | 12            | 12            | 12                       |    |
| 17                                  | Facilitate renewable energy         | 20   | 20       | 20       | 0        | 0                 | 9             | 9             | 2               | 2             | 9               | 10           | 27             | 0                    | 0                      | 15                   | 5                    | 6                       | 9                           | 18                           | 18                          | 15                | 15                    | 0             | 20              | 4             | 20            | 15            | 15            | 15                       |    |
| 18                                  | Lower project capital costs         | 3  | 0        | 0        | 12       | 25                | 20            | 36            | 36              | 20            | 20              | 45           | 0              | 12                   | 15                     | 0                    | 3                    | 12                      | 0                           | 20                           | 20                          | 20                | 4                     | 4             | 0               | 36            | 45            | 12            | 12            | 12                       |    |
| 19                                  | Reduce costs of carbon offset       | 15   | 20       | 15       | 9        | 12                | 1             | 0             | 0               | 6             | 2               | 18           | 3              | 6                    | 10                     | 25                   | 6                    | 6                       | 27                          | 36                           | 1                           | 3                 | 3                     | 1             | 20              | 1             | 6             | 5             | 5             | 5                        |    |
| 20                                  | Achieve higher rental rates         | 20   | 9        | 2        | 0        | 9                 | 1             | 0             | 0               | 3             | 9               | 12           | 0              | 0                    | 9                      | 6                    | 1                    | 1                       | 6                           | 6                            | 0                           | 9                 | 9                     | 0             | 9               | 2             | 2             | 9             | 12            | 12                       |    |
| 21                                  | Achieve higher occupancy rates      | 12   | 12       | 9        | 3        | 9                 | 1             | 27            | 18              | 2             | 3               | 9            | 15             | 3                    | 0                      | 9                    | 9                    | 2                       | 2                           | 10                           | 10                          | 3                 | 9                     | 2             | 1               | 6             | 2             | 2             | 9             | 12                       |    |
| 22                                  | Avoid costs due to opposition       | 20   | 2        | 3        | 2        | 4                 | 2             | 0             | 0               | 2             | 2               | 3            | 0              | 0                    | 4                      | 12                   | 3                    | 3                       | 9                           | 9                            | 6                           | 9                 | 0                     | 0             | 1               | 0             | 2             | 9             | 12            | 12                       |    |
| 23                                  | Gain the public's trust             | 12   | 12       | 12       | 4        | 4                 | 0             | 3             | 0               | 0             | 3               | 0            | 0              | 0                    | 3                      | 15                   | 4                    | 2                       | 9                           | 9                            | 6                           | 6                 | 0                     | 0             | 12              | 3             | 3             | 4             | 4             | 4                        |    |
| 24                                  | Decrease outages / interruptions    | 20   | 36       | 45       | 45       | 45                | 20            | 12            | 12              | 9             | 36              | 27           | 25             | 15                   | 9                      | 4                    | 25                   | 12                      | 27                          | 27                           | 10                          | 10                | 3                     | 3             | 36              | 3             | 4             | 20            | 12            | 12                       |    |
| 25                                  | Attract and retain employees        | 12   | 12       | 12       | 9        | 9                 | 1             | 15            | 25              | 15            | 9               | 4            | 4              | 12                   | 12                     | 5                    | 5                    | 12                      | 6                           | 15                           | 3                           | 10                | 10                    | 3             | 12              | 2             | 2             | 0             | 0             | 0                        |    |
| 26                                  | Improve occupant attendance         | 20   | 25       | 12       | 45       | 45                | 2             | 6             | 10              | 15            | 9               | 4            | 4              | 15                   | 10                     | 15                   | 2                    | 2                       | 27                          | 27                           | 2                           | 2                 | 2                     | 2             | 15              | 9             | 9             | 0             | 0             | 0                        |    |
| 27                                  | Improve occupant health             | 36   | 20       | 12       | 45       | 45                | 20            | 15            | 15              | 10            | 20              | 20           | 27             | 36                   | 10                     | 25                   | 6                    | 9                       | 27                          | 27                           | 15                          | 15                | 3                     | 3             | 20              | 15            | 10            | 9             | 9             | 9                        |    |
| 28                                  | Improve corporate reporting results | 9  | 45       | 25       | 20       | 9                 | 20            | 4             | 1               | 12            | 6               | 12           | 12             | 0                    | 0                      | 6                    | 12                   | 5                       | 3                           | 9                            | 9                           | 6                 | 4                     | 3             | 45              | 4             | 9             | 25            | 5             | 5                        |    |
| 29                                  | Diversify investment portfolios     | 10   | 15       | 2        | 0        | 9                 | 1             | 2             | 0               | 0             | 2               | 0            | 0              | 0                    | 2                      | 12                   | 2                    | 2                       | 12                          | 12                           | 6                           | 6                 | 0                     | 0             | 15              | 1             | 1             | 0             | 0             | 0                        |    |
| 30                                  | Leverage business platforms         | 12   | 45       | 25       | 20       | 9                 | 4             | 1             | 1               | 2             | 2               | 0            | 3              | 0                    | 0                      | 4                    | 12                   | 9                       | 9                           | 12                           | 4                           | 4                 | 2                     | 0             | 45              | 1             | 1             | 4             | 3             | 3                        |    |

**Table 26 – Mechanical System Technical Importance Rating Summary and Data Analysis Calculations, by Stakeholder Group**

| Potential Stakeholder Requirements: |                                     | Mechanical System Retrofits - Technical Importance |           |          |         |           |          |               |           |          |           |           |          |              |           |          |               |           |          |
|-------------------------------------|-------------------------------------|--|-----------|----------|---------|-----------|----------|---------------|-----------|----------|-----------|-----------|----------|--------------|-----------|----------|---------------|-----------|----------|
|                                     |                                     | Tenant   |           |          | Owner   |           |          | Facility Mgr. |           |          | Designers |           |          | Environmntl. |           |          | Weighted Avg. |           |          |
|                                     |                                     | Average  | Std. Dev. | Variance | Average | Std. Dev. | Variance | Average       | Std. Dev. | Variance | Average   | Std. Dev. | Variance | Average      | Std. Dev. | Variance | Average       | Std. Dev. | Variance |
| 1                                   | Reduce energy costs                 | 30   | 11        | 117      | 28.3    | 12        | 156      | 26.9          | 7         | 50       | 42.1      | 7         | 49       | 25           | 0         | 0        | 30.5          | 6.06      | 36.8     |
| 2                                   | Increase return on investment       | 30   | 11        | 117      | 25      | 16        | 267      | 22.5          | 3.5       | 13       | 29.3      | 14        | 189      | 20           | 0         | 0        | 25.4          | 3.85      | 14.8     |
| 3                                   | Minimize environmental impact       | 16.8   | 9.4       | 88       | 12.3    | 4.1       | 17       | 18.6          | 4.4       | 19       | 15.9      | 11        | 114      | 22.5         | 2.5       | 6.3      | 17.2          | 3.34      | 11.1     |
| 4                                   | Improve your organization's image   | 7.5  | 3.4       | 12       | 3.67    | 0.9       | 0.9      | 5.13          | 4.3       | 18       | 4.71      | 3.4       | 12       | 3            | 0         | 0        | 4.8           | 1.54      | 2.39     |
| 5                                   | Improve occupant comfort            | 28   | 14        | 206      | 29      | 9.9       | 98       | 27.8          | 6.9       | 48       | 24.9      | 8.6       | 74       | 15           | 0         | 0        | 24.9          | 5.15      | 26.5     |
| 6                                   | Increase energy efficiency          | 30   | 11        | 117      | 28.3    | 12        | 156      | 41.4          | 6.9       | 47       | 31.9      | 4.8       | 23       | 20           | 0         | 0        | 30.3          | 6.86      | 47       |
| 7                                   | Increase carbon neutrality          | 10.5   | 12        | 152      | 12.7    | 10        | 103      | 12.8          | 8.7       | 76       | 5.29      | 5.1       | 26       | 15           | 0         | 0        | 11.2          | 3.3       | 10.9     |
| 8                                   | Achieve lower total ownership costs | 26.2   | 14        | 185      | 29.2    | 11        | 128      | 29.5          | 10        | 104      | 29.1      | 14        | 209      | 25           | 0         | 0        | 27.8          | 1.85      | 3.41     |
| 9                                   | Meet regulatory requirements        | 10.7   | 6.8       | 46       | 14.2    | 8.6       | 75       | 23.3          | 13        | 178      | 5.57      | 4.9       | 24       | 25           | 0         | 0        | 15.7          | 7.4       | 54.8     |
| 10                                  | Comply with policy or legislation   | 28.3   | 12        | 147      | 21.7    | 4.7       | 22       | 25            | 8.7       | 75       | 15.9      | 14        | 190      | 25           | 0         | 0        | 23.2          | 4.22      | 17.8     |
| 11                                  | Improve aesthetic quality of site   | 0.33   | 0.7       | 0.6      | 0.67    | 0.9       | 0.9      | 1.63          | 1         | 1        | 2.29      | 2.5       | 6.5      | 0            | 0         | 0        | 0.98          | 0.85      | 0.72     |
| 12                                  | Improve occupant productivity       | 22.7   | 12        | 142      | 16      | 7.9       | 62       | 21.6          | 12        | 153      | 8.86      | 5.2       | 28       | 4            | 0         | 0        | 14.6          | 7.23      | 52.3     |
| 13                                  | Reduce chance of opposition         | 7  | 6.8       | 46       | 3       | 3         | 9        | 8.63          | 3.5       | 12       | 0.86      | 1.1       | 1.3      | 12           | 0         | 0        | 6.3           | 3.97      | 15.8     |
| 14                                  | Increase property value             | 8.67   | 5.3       | 29       | 7.67    | 8.6       | 74       | 8.25          | 7.5       | 56       | 6.29      | 3.5       | 12       | 4.5          | 1.5       | 2.3      | 7.07          | 1.52      | 2.3      |
| 15                                  | Reduce energy consumption           | 33.3   | 12        | 139      | 31.7    | 9.4       | 89       | 40            | 8.7       | 75       | 34.7      | 7.5       | 56       | 20           | 0         | 0        | 31.9          | 6.59      | 43.4     |
| 16                                  | Provide a secure energy supply      | 19.2   | 3.4       | 12       | 6.5     | 4.6       | 22       | 6.88          | 6.9       | 47       | 7.43      | 8.2       | 67       | 16           | 4         | 16       | 11.2          | 5.32      | 28.3     |
| 17                                  | Facilitate renewable energy         | 11.5   | 9         | 81       | 9.83    | 8.4       | 70       | 8.88          | 6.9       | 48       | 8.29      | 7.6       | 57       | 17.5         | 2.5       | 6.3      | 11.2          | 3.33      | 11.1     |
| 18                                  | Lower project capital costs         | 10   | 9.8       | 96       | 29.5    | 10        | 99       | 7.75          | 7.4       | 55       | 18.4      | 16        | 254      | 12           | 0         | 0        | 15.5          | 7.84      | 61.4     |
| 19                                  | Reduce costs of carbon offset       | 12   | 5.9       | 35       | 5.33    | 6.2       | 38       | 14.9          | 12        | 137      | 5         | 6.3       | 40       | 5            | 0         | 0        | 8.44          | 4.18      | 17.5     |
| 20                                  | Achieve higher rental rates         | 6.83   | 6.9       | 48       | 4       | 4.8       | 23       | 3.63          | 3.3       | 11       | 4.43      | 4         | 16       | 10.5         | 1.5       | 2.3      | 5.88          | 2.57      | 6.6      |
| 21                                  | Achieve higher occupancy rates      | 7.67   | 4.2       | 18       | 12.3    | 8.7       | 77       | 5.63          | 4         | 16       | 3.57      | 2.7       | 7.1      | 10.5         | 1.5       | 2.3      | 7.94          | 3.17      | 10.1     |
| 22                                  | Avoid costs due to opposition       | 5.5  | 6.5       | 43       | 1.67    | 1.2       | 1.6      | 5             | 4.2       | 18       | 2.57      | 3.3       | 11       | 10.5         | 1.5       | 2.3      | 5.05          | 3.08      | 9.5      |
| 23                                  | Gain the public's trust             | 7.33   | 4.9       | 24       | 1       | 1.4       | 2        | 5.25          | 4.9       | 24       | 4.29      | 3.9       | 15       | 4            | 0         | 0        | 4.37          | 2.05      | 4.21     |
| 24                                  | Decrease outages / interruptions    | 35.2   | 11        | 125      | 17.5    | 10        | 106      | 18            | 8.5       | 73       | 9.86      | 11        | 123      | 16           | 4         | 16       | 19.3          | 8.45      | 71.3     |
| 25                                  | Attract and retain employees        | 9.17   | 3.9       | 15       | 12      | 7.3       | 54       | 9.88          | 3.7       | 13       | 6         | 4.1       | 17       | 0            | 0         | 0        | 7.41          | 4.17      | 17.4     |
| 26                                  | Improve occupant attendance         | 24.8   | 16        | 254      | 8       | 3.9       | 15       | 14.1          | 9         | 81       | 5.86      | 4.8       | 23       | 0            | 0         | 0        | 10.6          | 8.45      | 71.3     |
| 27                                  | Improve occupant health             | 29.7   | 13        | 168      | 15      | 4.1       | 17       | 20.9          | 10        | 105      | 11.6      | 6         | 37       | 9            | 0         | 0        | 17.2          | 7.38      | 54.5     |
| 28                                  | Improve corporate reporting results | 21.3   | 12        | 147      | 7.83    | 4.4       | 19       | 5.5           | 4.1       | 17       | 11        | 14        | 196      | 15           | 10        | 100      | 12.1          | 5.6       | 31.3     |
| 29                                  | Diversify investment portfolios     | 6.17   | 5.5       | 30       | 0.67    | 0.9       | 0.9      | 5.25          | 5.3       | 28       | 4.14      | 5.1       | 26       | 0            | 0         | 0        | 3.25          | 2.47      | 6.11     |
| 30                                  | Leverage business platforms         | 19.2   | 13        | 181      | 1.5     | 1         | 0.9      | 6.25          | 4.6       | 21       | 7.57      | 15        | 235      | 3.5          | 0.5       | 0.3      | 7.6           | 6.16      | 37.9     |
| S                                   | Minimum                             | 0.3  |           |          | 0.7     |           |          | 1.6           |           |          | 0.9       |           |          | 0.0          |           |          | 1.0           |           |          |
| T                                   | 1st Quartile (lower 25%)            | 7.9  |           |          | 4.3     |           |          | 5.8           |           |          | 4.8       |           |          | 4.1          |           |          | 7.2           |           |          |
| A                                   | Median                              | 14.4   |           |          | 12.2    |           |          | 11.3          |           |          | 7.5       |           |          | 12.0         |           |          | 11.2          |           |          |
| T                                   | 3rd Quartile (upper 25%)            | 27.5   |           |          | 20.6    |           |          | 22.3          |           |          | 15.9      |           |          | 19.4         |           |          | 18.8          |           |          |
| S                                   | Maximum                             | 35.2   |           |          | 31.7    |           |          | 41.4          |           |          | 42.1      |           |          | 25.0         |           |          | 31.9          |           |          |

**Appendix D – HOQ Electrical System Retrofit Relationship Data, Technical Importance Calculations, and Data Analysis Calculations**

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**Table 27 – Electrical System Retrofits, Relationship Rating Survey Data: HOQ Survey Individual Participant Responses**

| Potential Stakeholder Requirements: |                                     | Electrical System Retrofits Vs. Stakeholder Requirements - Relationship Rating Data |          |          |          |                   |               |               |                 |               |                 |              |                |                      |                        |                      |                      |                         |                             |                              |                             |                   |                       |               |                   |               |                   |               |               |               |                          |   |   |
|-------------------------------------|-------------------------------------|---|----------|----------|----------|-------------------|---------------|---------------|-----------------|---------------|-----------------|--------------|----------------|----------------------|------------------------|----------------------|----------------------|-------------------------|-----------------------------|------------------------------|-----------------------------|-------------------|-----------------------|---------------|-------------------|---------------|-------------------|---------------|---------------|---------------|--------------------------|---|---|
|                                     |                                     | Tenant 4  | Tenant 3 | Tenant 2 | Tenant 1 | Tenant (Director) | Tenant (APWO) | Owner 1 (UEM) | Owner 2 (UEM-J) | Owner 3 (UEM) | Owner 4 (UEM-T) | Owner 5 (AM) | Owner 5 (AM-A) | Facility Mgr. 1 (CM) | Facility Mgr. 2 (CM-J) | Facility Mgr. 3 (EE) | Facility Mgr. 4 (ME) | Facility Mgr. 5 (Maint) | Facility Mgr. 6 (Maint - R) | Facility Mgr. 7 (Maint - K1) | Facility Mgr. 8 (Maint - K) | Designer (ME - B) | Designer 2 (ME - Byd) | Designer (ME) | Designer (ME - T) | Designer (PM) | Designer (PM - A) | Designer (CE) | Designer (TL) | Environmental | Environmental 2 (EV - S) |   |   |
| 1                                   | Reduce energy costs                 | 5   | 9        | 5        | 3        | 3                 | 5             | 5             | 5               | 5             | 5               | 5            | 5              | 5                    | 5                      | 1                    | 9                    | 9                       | 5                           | 3                            | 9                           | 9                 | 5                     | 3             | 3                 | 3             | 5                 | 9             | 0             | 5             | 3                        | 3 | 1 |
| 2                                   | Increase return on investment       | 5   | 5        | 5        | 3        | 3                 | 5             | 5             | 5               | 5             | 5               | 5            | 5              | 5                    | 5                      | 5                    | 5                    | 5                       | 5                           | 3                            | 9                           | 9                 | 5                     | 5             | 3                 | 3             | 5                 | 1             | 3             | 5             | 3                        | 1 |   |
| 3                                   | Minimize environmental impact       | 3   | 9        | 5        | 3        | 1                 | 3             | 1             | 3               | 3             | 1               | 3            | 3              | 3                    | 3                      | 3                    | 5                    | 5                       | 3                           | 1                            | 5                           | 5                 | 1                     | 1             | 1                 | 1             | 9                 | 1             | 1             | 5             | 3                        | 1 |   |
| 4                                   | Improve your organization's image   | 1   | 3        | 3        | 1        | 1                 | 1             | 1             | 1               | 1             | 1               | 1            | 3              | 3                    | 3                      | 1                    | 9                    | 9                       | 1                           | 3                            | 5                           | 3                 | 3                     | 1             | 1                 | 3             | 1                 | 3             | 1             | 3             | 3                        | 5 | 5 |
| 5                                   | Improve occupant comfort            | 3   | 3        | 3        | 3        | 3                 | 1             | 5             | 5               | 1             | 3               | 3            | 3              | 3                    | 3                      | 1                    | 3                    | 5                       | 3                           | 3                            | 5                           | 5                 | 1                     | 1             | 1                 | 3             | 3                 | 5             | 3             | 5             | 3                        | 1 |   |
| 6                                   | Increase energy efficiency          | 5   | 1        | 5        | 3        | 3                 | 5             | 9             | 5               | 5             | 5               | 5            | 9              | 9                    | 5                      | 9                    | 5                    | 9                       | 5                           | 5                            | 5                           | 5                 | 5                     | 5             | 5                 | 1             | 5                 | 9             | 5             | 3             | 1                        |   |   |
| 7                                   | Increase carbon neutrality          | 3   | 0        | 9        | 3        | 5                 | 1             | 5             | 5               | 5             | 5               | 9            | 9              | 3                    | 5                      | 5                    | 5                    | 5                       | 3                           | 9                            | 9                           | 1                 | 3                     | 3             | 1                 | 0             | 1                 | 1             | 5             | 5             | 5                        |   |   |
| 8                                   | Achieve lower total ownership costs | 5   | 3        | 5        | 3        | 1                 | 3             | 5             | 5               | 5             | 5               | 5            | 5              | 9                    | 5                      | 9                    | 5                    | 5                       | 5                           | 9                            | 1                           | 3                 | 3                     | 1             | 3                 | 3             | 1                 | 0             | 1             | 1             | 5                        | 5 |   |
| 9                                   | Meet regulatory requirements        | 5   | 3        | 3        | 1        | 1                 | 5             | 1             | 1               | 5             | 5               | 3            | 5              | 5                    | 5                      | 5                    | 9                    | 9                       | 3                           | 3                            | 5                           | 5                 | 3                     | 3             | 1                 | 3             | 3                 | 1             | 0             | 1             | 1                        |   |   |
| 10                                  | Comply with policy or legislation   | 5   | 9        | 5        | 3        | 1                 | 5             | 9             | 9               | 5             | 5               | 5            | 5              | 5                    | 5                      | 3                    | 9                    | 9                       | 5                           | 3                            | 5                           | 3                 | 3                     | 1             | 1                 | 9             | 3                 | 5             | 5             | 5             | 5                        |   |   |
| 11                                  | Improve aesthetic quality of site   | 0   | 1        | 1        | 0        | 0                 | 1             | 3             | 3               | 1             | 1               | 0            | 0              | 1                    | 1                      | 9                    | 9                    | 3                       | 3                           | 1                            | 1                           | 5                 | 5                     | 0             | 0                 | 1             | 3                 | 1             | 1             | 0             | 0                        |   |   |
| 12                                  | Improve occupant productivity       | 3   | 5        | 5        | 1        | 1                 | 3             | 1             | 5               | 5             | 1               | 3            | 3              | 5                    | 5                      | 5                    | 5                    | 5                       | 5                           | 5                            | 3                           | 3                 | 3                     | 1             | 1                 | 5             | 1                 | 1             | 1             | 1             | 1                        |   |   |
| 13                                  | Reduce chance of opposition         | 5   | 1        | 0        | 3        | 3                 | 1             | 1             | 1               | 3             | 3               | 1            | 1              | 1                    | 1                      | 3                    | 5                    | 1                       | 1                           | 3                            | 3                           | 0                 | 1                     | 1             | 0                 | 1             | 0                 | 0             | 0             | 5             | 5                        |   |   |
| 14                                  | Increase property value             | 3   | 3        | 3        | 3        | 9                 | 1             | 1             | 1               | 1             | 1               | 3            | 5              | 3                    | 3                      | 1                    | 5                    | 3                       | 3                           | 9                            | 1                           | 1                 | 1                     | 1             | 1                 | 3             | 1                 | 1             | 3             | 1             | 1                        |   |   |
| 15                                  | Reduce energy consumption           | 5   | 9        | 5        | 3        | 3                 | 5             | 5             | 5               | 5             | 5               | 9            | 9              | 9                    | 9                      | 5                    | 9                    | 5                       | 5                           | 9                            | 3                           | 3                 | 3                     | 3             | 3                 | 9             | 3                 | 3             | 9             | 5             | 5                        |   |   |
| 16                                  | Provide a secure energy supply      | 9   | 0        | 5        | 5        | 9                 | 5             | 1             | 1               | 1             | 1               | 1            | 1              | 1                    | 9                      | 9                    | 1                    | 9                       | 3                           | 1                            | 5                           | 3                 | 3                     | 1             | 1                 | 0             | 0                 | 5             | 5             | 5             | 5                        |   |   |
| 17                                  | Facilitate renewable energy         | 5   | 0        | 5        | 3        | 5                 | 3             | 3             | 3               | 3             | 1               | 1            | 5              | 5                    | 9                      | 5                    | 9                    | 5                       | 5                           | 9                            | 3                           | 3                 | 5                     | 5             | 0                 | 0             | 0                 | 3             | 5             | 5             | 5                        |   |   |
| 18                                  | Lower project capital costs         | 1   | 1        | 0        | 3        | 5                 | 5             | 5             | 3               | 3             | 5               | 3            | 5              | 0                    | 5                      | 0                    | 0                    | 1                       | 3                           | 5                            | 3                           | 3                 | 1                     | 1             | 1                 | 0             | 9                 | 9             | 3             | 3             | 3                        |   |   |
| 19                                  | Reduce costs of carbon offset       | 5   | 0        | 5        | 3        | 9                 | 1             | 0             | 0               | 3             | 9               | 3            | 9              | 3                    | 9                      | 3                    | 9                    | 3                       | 3                           | 5                            | 9                           | 1                 | 3                     | 3             | 1                 | 0             | 0                 | 1             | 3             | 5             | 5                        |   |   |
| 20                                  | Achieve higher rental rates         | 5   | 1        | 1        | 0        | 9                 | 1             | 1             | 1               | 3             | 3               | 0            | 3              | 0                    | 3                      | 3                    | 3                    | 3                       | 1                           | 0                            | 3                           | 0                 | 3                     | 3             | 0                 | 1             | 0                 | 0             | 1             | 3             | 3                        |   |   |
| 21                                  | Achieve higher occupancy rates      | 3   | 3        | 3        | 1        | 9                 | 1             | 1             | 3               | 3             | 1               | 1            | 3              | 1                    | 3                      | 1                    | 3                    | 3                       | 1                           | 1                            | 0                           | 5                 | 5                     | 0             | 3                 | 0             | 0                 | 1             | 3             | 3             | 3                        |   |   |
| 22                                  | Avoid costs due to opposition       | 5   | 1        | 1        | 1        | 1                 | 1             | 1             | 1               | 1             | 1               | 1            | 1              | 0                    | 0                      | 1                    | 5                    | 1                       | 1                           | 3                            | 0                           | 1                 | 1                     | 0             | 1                 | 0             | 1                 | 1             | 3             | 3             |                          |   |   |
| 23                                  | Gain the public's trust             | 3   | 3        | 3        | 1        | 1                 | 1             | 0             | 0               | 1             | 1               | 0            | 0              | 0                    | 0                      | 1                    | 5                    | 1                       | 1                           | 3                            | 3                           | 1                 | 1                     | 0             | 0                 | 3             | 1                 | 1             | 1             | 3             | 1                        |   |   |
| 24                                  | Decrease outages / interruptions    | 5   | 5        | 3        | 9        | 9                 | 5             | 5             | 3               | 3             | 5               | 3            | 9              | 3                    | 9                      | 5                    | 9                    | 5                       | 3                           | 3                            | 9                           | 3                 | 3                     | 1             | 1                 | 5             | 0                 | 5             | 5             | 5             | 5                        |   |   |
| 25                                  | Attract and retain employees        | 3   | 3        | 3        | 1        | 1                 | 1             | 3             | 3               | 1             | 1               | 1            | 1              | 3                    | 5                      | 1                    | 1                    | 5                       | 5                           | 5                            | 1                           | 5                 | 5                     | 1             | 5                 | 3             | 1                 | 1             | 1             | 0             | 0                        |   |   |
| 26                                  | Improve occupant attendance         | 5   | 3        | 3        | 3        | 3                 | 1             | 3             | 3               | 3             | 1               | 1            | 3              | 3                    | 3                      | 3                    | 3                    | 1                       | 1                           | 5                            | 0                           | 1                 | 1                     | 0             | 3                 | 1             | 0                 | 3             | 0             | 0             |                          |   |   |
| 27                                  | Improve occupant health             | 5   | 3        | 3        | 1        | 1                 | 3             | 3             | 3               | 1             | 1               | 3            | 3              | 5                    | 5                      | 1                    | 1                    | 3                       | 3                           | 1                            | 1                           | 1                 | 1                     | 1             | 1                 | 3             | 0                 | 1             | 1             | 1             | 1                        |   |   |
| 28                                  | Improve corporate reporting results | 3   | 9        | 5        | 5        | 9                 | 5             | 1             | 1               | 1             | 1               | 3            | 3              | 5                    | 5                      | 3                    | 3                    | 3                       | 3                           | 3                            | 1                           | 1                 | 1                     | 1             | 1                 | 9             | 1                 | 3             | 3             | 9             | 1                        |   |   |
| 29                                  | Diversify investment portfolios     | 3   | 3        | 1        | 0        | 9                 | 1             | 1             | 1               | 1             | 1               | 0            | 0              | 0                    | 0                      | 1                    | 3                    | 1                       | 1                           | 3                            | 3                           | 0                 | 3                     | 3             | 0                 | 3             | 0                 | 1             | 1             | 0             | 0                        |   |   |
| 30                                  | Leverage business platforms         | 1   | 9        | 5        | 5        | 5                 | 1             | 0             | 0               | 1             | 1               | 0            | 1              | 1                    | 3                      | 1                    | 3                    | 3                       | 3                           | 3                            | 1                           | 1                 | 1                     | 0             | 0                 | 9             | 0                 | 1             | 1             | 1             | 1                        |   |   |

**Table 28 – Electrical System Technical Importance Calculations: Results for each Individual Participant**

| Potential Stakeholder Requirements:     | Electrical System Retrofit - Summary of Technical Importance |          |          |          |                   |               |               |                 |               |                 |               |                |                      |                        |                      |                      |                         |                             |                              |                             |                   |                       |               |                 |               |                   |               |               |               |                          |
|---|--|----------|----------|----------|-------------------|---------------|---------------|-----------------|---------------|-----------------|---------------|----------------|----------------------|------------------------|----------------------|----------------------|-------------------------|-----------------------------|------------------------------|-----------------------------|-------------------|-----------------------|---------------|-----------------|---------------|-------------------|---------------|---------------|---------------|--------------------------|
|   | Tenant 4   | Tenant 3 | Tenant 2 | Tenant 1 | Tenant (Director) | Tenant (APWO) | Owner 1 (UEM) | Owner 2 (UEM-J) | Owner 3 (UEM) | Owner 4 (UEM-T) | Owner 5 (AMI) | Owner 5 (AM-A) | Facility Mgr. 1 (CM) | Facility Mgr. 2 (CM-J) | Facility Mgr. 3 (EE) | Facility Mgr. 4 (ME) | Facility Mgr. 5 (Maint) | Facility Mgr. 6 (Maint - R) | Facility Mgr. 7 (Maint - K1) | Facility Mgr. 8 (Maint - K) | Designer (ME - B) | Designer 2 (ME - Byd) | Designer (ME) | Designer (ME-T) | Designer (PM) | Designer (PM - A) | Designer (CE) | Designer (TT) | Environmental | Environmental 2 (EV - S) |
| 1. Reduce energy costs                  | 20   | 45       | 25       | 15       | 12                | 25            | 25            | 25              | 25            | 25              | 25            | 25             | 25                   | 25                     | 45                   | 45                   | 25                      | 15                          | 45                           | 36                          | 25                | 15                    | 15            | 25              | 45            | 0                 | 25            | 15            | 15            | 5                        |
| 2. Increase return on investment        | 20   | 25       | 25       | 15       | 15                | 20            | 25            | 25              | 25            | 25              | 25            | 25             | 25                   | 25                     | 20                   | 20                   | 25                      | 15                          | 45                           | 45                          | 25                | 15                    | 15            | 25              | 25            | 4                 | 12            | 20            | 12            | 4                        |
| 3. Minimize environmental impact        | 9  | 36       | 15       | 12       | 3                 | 12            | 4             | 9               | 12            | 3               | 9             | 9              | 20                   | 12                     | 15                   | 25                   | 12                      | 3                           | 20                           | 20                          | 3                 | 4                     | 2             | 36              | 4             | 4                 | 15            | 25            | 12            | 4                        |
| 4. Improve your organization's image    | 4  | 12       | 9        | 3        | 3                 | 2             | 3             | 3               | 3             | 3               | 15            | 15             | 9                    | 3                      | 27                   | 45                   | 3                       | 9                           | 10                           | 9                           | 6                 | 6                     | 2             | 2               | 12            | 3                 | 6             | 9             | 15            | 15                       |
| 5. Improve occupant comfort             | 9  | 12       | 12       | 15       | 15                | 9             | 3             | 20              | 20            | 3               | 12            | 12             | 9                    | 4                      | 12                   | 20                   | 20                      | 12                          | 9                            | 10                          | 10                | 3                     | 3             | 12              | 12            | 20                | 20            | 9             | 3             |                          |
| 6. Increase energy efficiency           | 20   | 5        | 25       | 15       | 12                | 25            | 45            | 45              | 25            | 25              | 25            | 25             | 45                   | 45                     | 25                   | 45                   | 25                      | 45                          | 36                           | 20                          | 20                | 15                    | 15            | 5               | 20            | 36                | 36            | 20            | 12            |                          |
| 7. Increase carbon neutrality           | 9  | 0        | 36       | 6        | 10                | 1             | 10            | 10              | 5             | 5               | 27            | 27             | 6                    | 10                     | 5                    | 25                   | 15                      | 9                           | 9                            | 27                          | 0                 | 3                     | 3             | 0               | 0             | 3                 | 2             | 10            | 15            | 15                       |
| 8. Achieve lower total ownership costs  | 20   | 15       | 20       | 15       | 5                 | 12            | 25            | 20              | 20            | 20              | 25            | 25             | 45                   | 45                     | 25                   | 45                   | 20                      | 20                          | 25                           | 36                          | 5                 | 12                    | 15            | 3               | 15            | 12                | 5             | 45            | 25            | 25                       |
| 9. Meet regulatory requirements         | 20   | 9        | 6        | 4        | 5                 | 20            | 5             | 3               | 15            | 25              | 12            | 25             | 25                   | 25                     | 45                   | 45                   | 12                      | 15                          | 20                           | 9                           | 12                | 4                     | 3             | 9               | 15            | 4                 | 0             | 5             | 5             |                          |
| 10. Comply with policy or legislation   | 20   | 45       | 25       | 15       | 5                 | 20            | 27            | 27              | 25            | 25              | 25            | 25             | 15                   | 15                     | 45                   | 45                   | 25                      | 15                          | 25                           | 25                          | 12                | 12                    | 3             | 3               | 45            | 15                | 20            | 20            | 25            | 25                       |
| 11. Improve aesthetic quality of site   | 0  | 3        | 2        | 0        | 0                 | 2             | 6             | 6               | 2             | 2               | 0             | 0              | 3                    | 2                      | 18                   | 18                   | 6                       | 6                           | 3                            | 3                           | 10                | 10                    | 0             | 0               | 3             | 0                 | 1             | 3             | 0             | 0                        |
| 12. Improve occupant productivity       | 12   | 25       | 15       | 5        | 5                 | 6             | 3             | 15              | 20            | 4               | 9             | 15             | 15                   | 20                     | 25                   | 20                   | 20                      | 20                          | 20                           | 12                          | 9                 | 9                     | 3             | 3               | 20            | 3                 | 3             | 4             | 4             |                          |
| 13. Reduce chance of opposition         | 20   | 2        | 0        | 9        | 9                 | 2             | 1             | 1               | 3             | 9               | 3             | 3              | 3                    | 3                      | 12                   | 20                   | 3                       | 3                           | 9                            | 12                          | 0                 | 3                     | 2             | 0               | 1             | 0                 | 0             | 0             | 20            | 20                       |
| 14. Increase property value             | 12   | 9        | 6        | 6        | 18                | 1             | 0             | 0               | 3             | 3               | 9             | 25             | 3                    | 3                      | 2                    | 15                   | 6                       | 9                           | 9                            | 27                          | 1                 | 3                     | 2             | 1               | 9             | 1                 | 3             | 9             | 1             | 2                        |
| 15. Reduce energy consumption           | 20   | 45       | 25       | 15       | 12                | 25            | 25            | 25              | 25            | 25              | 25            | 45             | 45                   | 45                     | 25                   | 45                   | 25                      | 25                          | 45                           | 45                          | 9                 | 12                    | 12            | 9               | 45            | 12                | 9             | 45            | 20            | 20                       |
| 16. Provide a secure energy supply      | 27   | 0        | 20       | 15       | 45                | 20            | 5             | 5               | 2             | 2               | 3             | 2              | 45                   | 45                     | 2                    | 27                   | 9                       | 2                           | 20                           | 15                          | 9                 | 9                     | 2             | 2               | 0             | 0                 | 10            | 10            | 20            | 20                       |
| 17. Facilitate renewable energy         | 20   | 0        | 20       | 6        | 10                | 9             | 9             | 6               | 6             | 9               | 2             | 3              | 20                   | 20                     | 45                   | 45                   | 10                      | 15                          | 18                           | 18                          | 9                 | 9                     | 10            | 10              | 0             | 0                 | 10            | 10            | 20            | 15                       |
| 18. Lower project capital costs         | 3  | 0        | 0        | 12       | 25                | 20            | 20            | 20              | 12            | 12              | 12            | 25             | 0                    | 20                     | 0                    | 0                    | 3                       | 12                          | 0                            | 20                          | 12                | 12                    | 4             | 4               | 0             | 0                 | 36            | 45            | 12            | 12                       |
| 19. Reduce costs of carbon offset       | 15   | 0        | 15       | 9        | 36                | 1             | 0             | 0               | 6             | 6               | 18            | 18             | 3                    | 6                      | 18                   | 45                   | 6                       | 6                           | 15                           | 36                          | 1                 | 3                     | 3             | 1               | 0             | 0                 | 1             | 6             | 5             | 5                        |
| 20. Achieve higher rental rates         | 20   | 3        | 2        | 0        | 9                 | 1             | 0             | 0               | 9             | 9               | 12            | 0              | 0                    | 9                      | 6                    | 1                    | 1                       | 0                           | 6                            | 0                           | 9                 | 9                     | 0             | 3               | 0             | 0                 | 0             | 2             | 9             | 12                       |
| 21. Achieve higher occupancy rates      | 12   | 12       | 9        | 1        | 9                 | 1             | 3             | 6               | 6             | 3               | 3             | 15             | 1                    | 0                      | 3                    | 9                    | 6                       | 6                           | 2                            | 2                           | 0                 | 15                    | 10            | 0               | 6             | 0                 | 0             | 2             | 9             | 12                       |
| 22. Avoid costs due to opposition       | 20   | 2        | 3        | 2        | 4                 | 2             | 1             | 1               | 2             | 2               | 3             | 3              | 0                    | 4                      | 20                   | 3                    | 3                       | 9                           | 9                            | 0                           | 3                 | 1                     | 0             | 1               | 0             | 2                 | 2             | 9             | 12            | 12                       |
| 23. Gain the public's trust             | 12   | 12       | 12       | 4        | 4                 | 0             | 0             | 0               | 3             | 3               | 0             | 0              | 0                    | 0                      | 3                    | 25                   | 4                       | 2                           | 9                            | 9                           | 2                 | 2                     | 0             | 0               | 12            | 0                 | 3             | 3             | 12            | 4                        |
| 24. Decrease outages / interruptions    | 20   | 20       | 15       | 45       | 45                | 20            | 20            | 12              | 9             | 15              | 12            | 27             | 15                   | 45                     | 15                   | 36                   | 25                      | 12                          | 9                            | 27                          | 6                 | 6                     | 3             | 3               | 20            | 0                 | 15            | 20            | 20            | 20                       |
| 25. Attract and retain employees        | 12   | 12       | 12       | 3        | 3                 | 1             | 9             | 15              | 5             | 3               | 4             | 4              | 12                   | 20                     | 5                    | 5                    | 20                      | 20                          | 10                           | 15                          | 3                 | 10                    | 10            | 3               | 12            | 3                 | 2             | 2             | 0             | 0                        |
| 26. Improve occupant attendance         | 20   | 15       | 12       | 15       | 15                | 2             | 6             | 6               | 9             | 9               | 4             | 4              | 9                    | 6                      | 15                   | 15                   | 2                       | 2                           | 15                           | 15                          | 0                 | 2                     | 2             | 0               | 9             | 2                 | 0             | 9             | 0             | 0                        |
| 27. Improve occupant health             | 20   | 12       | 12       | 5        | 5                 | 12            | 9             | 9               | 2             | 2               | 12            | 12             | 15                   | 20                     | 2                    | 5                    | 6                       | 9                           | 3                            | 3                           | 3                 | 3                     | 3             | 3               | 12            | 0                 | 3             | 2             | 3             | 3                        |
| 28. Improve corporate reporting/results | 9  | 45       | 25       | 20       | 27                | 20            | 4             | 1               | 4             | 2               | 12            | 12             | 20                   | 20                     | 6                    | 12                   | 15                      | 9                           | 9                            | 9                           | 2                 | 2                     | 4             | 3               | 45            | 3                 | 12            | 9             | 45            | 5                        |
| 29. Diversify investment portfolios     | 6  | 9        | 2        | 0        | 9                 | 1             | 2             | 1               | 1             | 2               | 0             | 0              | 0                    | 0                      | 2                    | 12                   | 2                       | 2                           | 12                           | 12                          | 0                 | 6                     | 3             | 0               | 9             | 0                 | 1             | 1             | 0             | 0                        |
| 30. Leverage business platforms         | 4  | 45       | 25       | 20       | 5                 | 4             | 0             | 0               | 2             | 2               | 0             | 3              | 6                    | 4                      | 12                   | 9                    | 9                       | 12                          | 4                            | 4                           | 4                 | 2                     | 0             | 0               | 45            | 0                 | 1             | 1             | 4             | 3                        |

**Table 29 – Electrical System Technical Importance Rating Summary and Data Analysis Calculations, by Stakeholder Group**

| Potential Stakeholder Requirements: |                                     | Electrical System Retrofits - Technical Importance |           |          |         |           |          |               |           |          |           |           |          |              |           |          |               |           |          |  |  |  |
|-------------------------------------|-------------------------------------|--|-----------|----------|---------|-----------|----------|---------------|-----------|----------|-----------|-----------|----------|--------------|-----------|----------|---------------|-----------|----------|--|--|--|
|                                     |                                     | Tenant   |           |          | Owner   |           |          | Facility Mgr. |           |          | Designers |           |          | Environmntl. |           |          | Weighted Avg. |           |          |  |  |  |
|                                     |                                     | Average  | Std. Dev. | Variance | Average | Std. Dev. | Variance | Average       | Std. Dev. | Variance | Average   | Std. Dev. | Variance | Average      | Std. Dev. | Variance | Average       | Std. Dev. | Variance |  |  |  |
| 1                                   | Reduce energy costs                 | 23.7   | 11        | 114      | 25      | 0         | 0        | 30.1          | 14        | 201      | 23.6      | 9.9       | 98       | 10           | 5         | 25       | 22.5          | 6.68      | 44.6     |  |  |  |
| 2                                   | Increase return on investment       | 20   | 4.1       | 17       | 25      | 0         | 0        | 27.5          | 11        | 113      | 19.6      | 5.2       | 27       | 8            | 4         | 16       | 20            | 6.71      | 45.1     |  |  |  |
| 3                                   | Minimize environmental impact       | 14.5   | 10        | 106      | 7.67    | 3.1       | 9.9      | 15.9          | 6.4       | 41       | 9.57      | 12        | 133      | 18.5         | 6.5       | 42       | 13.2          | 4.02      | 16.1     |  |  |  |
| 4                                   | Improve your organization's image   | 5.5  | 3.7       | 14       | 7       | 5.7       | 32       | 14.4          | 14        | 183      | 6.14      | 3.3       | 11       | 15           | 0         | 0        | 9.6           | 4.18      | 17.5     |  |  |  |
| 5                                   | Improve occupant comfort            | 12   | 2.4       | 6        | 11.7    | 6.9       | 48       | 12.3          | 5.1       | 26       | 11.1      | 6.5       | 42       | 6            | 3         | 9        | 10.6          | 2.34      | 5.45     |  |  |  |
| 6                                   | Increase energy efficiency          | 17   | 7.2       | 52       | 31.7    | 9.4       | 89       | 36.4          | 9.3       | 86       | 21        | 11        | 111      | 16           | 4         | 16       | 24.4          | 8.16      | 66.6     |  |  |  |
| 7                                   | Increase carbon neutrality          | 10.3   | 12        | 146      | 14      | 9.4       | 89       | 13.3          | 7.9       | 62       | 2.57      | 3.3       | 11       | 15           | 0         | 0        | 11            | 4.51      | 20.3     |  |  |  |
| 8                                   | Achieve lower total ownership costs | 14.5   | 5.1       | 26       | 22.5    | 2.5       | 6.3      | 29.5          | 10        | 104      | 14.3      | 13        | 178      | 25           | 0         | 0        | 21.2          | 5.96      | 35.5     |  |  |  |
| 9                                   | Meet regulatory requirements        | 10.7   | 6.8       | 46       | 14.2    | 8.6       | 75       | 25.3          | 12        | 149      | 5.86      | 3.9       | 15       | 5            | 0         | 0        | 12.2          | 7.33      | 53.7     |  |  |  |
| 10                                  | Comply with policy or legislation   | 21.7   | 12        | 147      | 25.7    | 0.9       | 0.9      | 27.5          | 11        | 119      | 16.4      | 13        | 177      | 25           | 0         | 0        | 23.3          | 3.9       | 15.2     |  |  |  |
| 11                                  | Improve aesthetic quality of site   | 1.17   | 1.2       | 1.5      | 2.67    | 2.5       | 6.2      | 7.38          | 6.3       | 39       | 3.86      | 4.1       | 16       | 0            | 0         | 0        | 3.01          | 2.54      | 6.47     |  |  |  |
| 12                                  | Improve occupant productivity       | 11.3   | 7.2       | 52       | 10      | 5.9       | 35       | 18.4          | 3.8       | 15       | 7.14      | 5.9       | 34       | 4            | 0         | 0        | 10.2          | 4.82      | 23.2     |  |  |  |
| 13                                  | Reduce chance of opposition         | 7  | 6.8       | 46       | 3.33    | 2.7       | 7.2      | 8.13          | 5.9       | 35       | 0.86      | 1.1       | 1.3      | 20           | 0         | 0        | 7.86          | 6.6       | 43.5     |  |  |  |
| 14                                  | Increase property value             | 8.67   | 5.3       | 29       | 6.67    | 8.7       | 76       | 9.25          | 7.8       | 61       | 4         | 3.3       | 11       | 1.5          | 0.5       | 0.3      | 6.02          | 2.91      | 8.47     |  |  |  |
| 15                                  | Reduce energy consumption           | 23.7   | 11        | 114      | 28.3    | 7.5       | 56       | 37.5          | 9.7       | 94       | 20.1      | 16        | 249      | 20           | 0         | 0        | 25.9          | 6.53      | 42.7     |  |  |  |
| 16                                  | Provide a secure energy supply      | 21.2   | 13        | 182      | 3.17    | 1.3       | 1.8      | 20.6          | 16        | 261      | 6         | 4.1       | 17       | 20           | 0         | 0        | 14.2          | 7.9       | 62.5     |  |  |  |
| 17                                  | Facilitate renewable energy         | 10.8   | 7.2       | 52       | 5.83    | 2.7       | 7.1      | 23.9          | 13        | 158      | 8.86      | 3.8       | 14       | 17.5         | 2.5       | 6.3      | 13.4          | 6.5       | 42.2     |  |  |  |
| 18                                  | Lower project capital costs         | 10   | 9.8       | 96       | 16.8    | 5.1       | 26       | 6.88          | 8.5       | 72       | 16.1      | 16        | 260      | 12           | 0         | 0        | 12.4          | 3.74      | 14       |  |  |  |
| 19                                  | Reduce costs of carbon offset       | 12.7   | 12        | 144      | 8       | 7.5       | 56       | 16.9          | 15        | 214      | 2.14      | 1.9       | 3.6      | 5            | 0         | 0        | 8.94          | 5.28      | 27.9     |  |  |  |
| 20                                  | Achieve higher rental rates         | 5.83   | 7         | 48       | 5       | 5.1       | 26       | 2.88          | 3.3       | 11       | 3.29      | 3.8       | 14       | 10.5         | 1.5       | 2.3      | 5.5           | 2.73      | 7.43     |  |  |  |
| 21                                  | Achieve higher occupancy rates      | 7.33   | 4.6       | 22       | 6       | 4.2       | 18       | 3.63          | 2.9       | 8.2      | 4.71      | 5.5       | 30       | 10.5         | 1.5       | 2.3      | 6.43          | 2.38      | 5.68     |  |  |  |
| 22                                  | Avoid costs due to opposition       | 5.5  | 6.5       | 43       | 2       | 0.8       | 0.7      | 6             | 6.2       | 39       | 1.29      | 1         | 1.1      | 10.5         | 1.5       | 2.3      | 5.06          | 3.29      | 10.9     |  |  |  |
| 23                                  | Gain the public's trust             | 7.33   | 4.9       | 24       | 1       | 1.4       | 2        | 6.5           | 7.7       | 60       | 3.14      | 3.8       | 14       | 8            | 4         | 16       | 5.2           | 2.68      | 7.19     |  |  |  |
| 24                                  | Decrease outages / interruptions    | 27.5   | 13        | 156      | 15.8    | 6         | 36       | 23            | 12        | 140      | 10.4      | 7.1       | 51       | 20           | 0         | 0        | 19.4          | 5.87      | 34.4     |  |  |  |
| 25                                  | Attract and retain employees        | 7.17   | 4.9       | 24       | 6.67    | 4.2       | 18       | 13.4          | 6         | 36       | 6         | 4.1       | 17       | 0            | 0         | 0        | 6.64          | 4.25      | 18       |  |  |  |
| 26                                  | Improve occupant attendance         | 13.2   | 5.5       | 30       | 6.33    | 2.1       | 4.2      | 9.88          | 5.5       | 31       | 3.14      | 3.8       | 14       | 0            | 0         | 0        | 6.5           | 4.68      | 21.9     |  |  |  |
| 27                                  | Improve occupant health             | 11   | 5.1       | 26       | 7.67    | 4.2       | 18       | 7.88          | 6.1       | 37       | 4.14      | 3.2       | 10       | 3            | 0         | 0        | 6.74          | 2.86      | 8.21     |  |  |  |
| 28                                  | Improve corporate reporting results | 24.3   | 11        | 118      | 5.83    | 4.5       | 20       | 12.5          | 5         | 25       | 11        | 14        | 205      | 25           | 20        | 400      | 15.7          | 7.62      | 58.1     |  |  |  |
| 29                                  | Diversify investment portfolios     | 4.5  | 3.7       | 14       | 1       | 0.8       | 0.7      | 5.25          | 5.3       | 28       | 2.86      | 3.2       | 10       | 0            | 0         | 0        | 2.72          | 2         | 3.99     |  |  |  |
| 30                                  | Leverage business platforms         | 17.2   | 15        | 223      | 1.17    | 1.2       | 1.5      | 7.38          | 3.4       | 11       | 7.57      | 15        | 235      | 3.5          | 0.5       | 0.3      | 7.36          | 5.47      | 29.9     |  |  |  |
| S                                   | Minimum                             | 1.2  |           |          | 1.0     |           |          | 2.9           |           |          | 0.9       |           |          | 0.0          |           |          | 2.7           |           |          |  |  |  |
| T                                   | 1st Quartile (lower 25%)            | 7.3  |           |          | 5.2     |           |          | 7.5           |           |          | 3.4       |           |          | 4.3          |           |          | 7.5           |           |          |  |  |  |
| A                                   | Median                              | 11.2   |           |          | 7.3     |           |          | 13.3          |           |          | 6.1       |           |          | 10.5         |           |          | 10.4          |           |          |  |  |  |
| T                                   | 3rd Quartile (upper 25%)            | 17.1   |           |          | 15.4    |           |          | 23.7          |           |          | 11.1      |           |          | 18.3         |           |          | 16.6          |           |          |  |  |  |
| S                                   | Maximum                             | 27.5   |           |          | 31.7    |           |          | 37.5          |           |          | 23.6      |           |          | 25.0         |           |          | 25.9          |           |          |  |  |  |

**Table 30 – Pooled Variance t-Test Results for Two Independent Populations:  
Facility Managers and Designers**

| Pooled Variance t-Test Results: Facility Manager Vs. Designer |       |      |        |       |      |           |       |            |          |
|---|-------|------|--------|-------|------|-----------|-------|------------|----------|
| Mean FM   | SD FM | n FM | Mean D | SD D  | n D  | Pooled SD | t_0   | Critical t | Sig.     |
| 37.50   | 10.35 | 8.00 | 20.14  | 17.03 | 8.00 | 14.09     | 2.46  | 2.62       | not sig. |
| 36.38   | 9.90  | 8.00 | 21.00  | 11.40 | 8.00 | 10.68     | 2.88  | 2.62       | sig.     |
| 30.13   | 15.17 | 8.00 | 23.57  | 10.69 | 8.00 | 13.12     | 1.00  | 2.62       | not sig. |
| 29.50   | 10.92 | 8.00 | 14.29  | 14.43 | 8.00 | 12.79     | 2.38  | 2.62       | not sig. |
| 27.50   | 11.34 | 8.00 | 19.57  | 5.59  | 8.00 | 8.94      | 1.77  | 2.62       | not sig. |
| 27.50   | 11.65 | 8.00 | 16.43  | 14.39 | 8.00 | 13.09     | 1.69  | 2.62       | not sig. |
| 25.25   | 13.06 | 8.00 | 5.86   | 4.22  | 8.00 | 9.70      | 4.00  | 2.62       | sig.     |
| 23.88   | 13.43 | 8.00 | 8.86   | 4.10  | 8.00 | 9.93      | 3.02  | 2.62       | sig.     |
| 23.00   | 12.64 | 8.00 | 10.43  | 7.68  | 8.00 | 10.46     | 2.40  | 2.62       | not sig. |
| 20.63   | 17.28 | 8.00 | 6.00   | 4.43  | 8.00 | 12.61     | 2.32  | 2.62       | not sig. |
| 18.38   | 4.10  | 8.00 | 7.14   | 6.34  | 8.00 | 5.34      | 4.21  | 2.62       | sig.     |
| 16.88   | 15.62 | 8.00 | 2.14   | 2.04  | 8.00 | 11.14     | 2.64  | 2.62       | sig.     |
| 15.88   | 6.88  | 8.00 | 9.57   | 12.47 | 8.00 | 10.07     | 1.25  | 2.62       | not sig. |
| 14.38   | 14.45 | 8.00 | 6.14   | 3.58  | 8.00 | 10.53     | 1.56  | 2.62       | not sig. |
| 13.38   | 6.41  | 8.00 | 6.00   | 4.43  | 8.00 | 5.51      | 2.68  | 2.62       | sig.     |
| 13.25   | 8.43  | 8.00 | 2.57   | 3.55  | 8.00 | 6.47      | 3.30  | 2.62       | sig.     |
| 12.50   | 5.32  | 8.00 | 11.00  | 15.47 | 8.00 | 11.57     | 0.26  | 2.62       | not sig. |
| 12.25   | 5.47  | 8.00 | 11.14  | 6.99  | 8.00 | 6.27      | 0.35  | 2.62       | not sig. |
| 9.88  | 5.91  | 8.00 | 3.14   | 4.10  | 8.00 | 5.09      | 2.65  | 2.62       | sig.     |
| 9.25  | 8.36  | 8.00 | 4.00   | 3.51  | 8.00 | 6.41      | 1.64  | 2.62       | not sig. |
| 8.13  | 6.29  | 8.00 | 0.86   | 1.21  | 8.00 | 4.53      | 3.21  | 2.62       | sig.     |
| 7.88  | 6.47  | 8.00 | 4.14   | 3.48  | 8.00 | 5.20      | 1.44  | 2.62       | not sig. |
| 7.38  | 6.72  | 8.00 | 3.86   | 4.38  | 8.00 | 5.67      | 1.24  | 2.62       | not sig. |
| 7.38  | 3.62  | 8.00 | 7.57   | 16.56 | 8.00 | 11.99     | -0.03 | 2.62       | not sig. |
| 6.88  | 9.06  | 8.00 | 16.14  | 17.40 | 8.00 | 13.87     | -1.34 | 2.62       | not sig. |
| 6.50  | 8.26  | 8.00 | 3.14   | 4.10  | 8.00 | 6.52      | 1.03  | 2.62       | not sig. |
| 6.00  | 6.63  | 8.00 | 1.29   | 1.11  | 8.00 | 4.76      | 1.98  | 2.62       | not sig. |
| 5.25  | 5.65  | 8.00 | 2.86   | 3.44  | 8.00 | 4.68      | 1.02  | 2.62       | not sig. |
| 3.63  | 3.07  | 8.00 | 4.71   | 5.91  | 8.00 | 4.71      | -0.46 | 2.62       | not sig. |
| 2.88  | 3.56  | 8.00 | 3.29   | 4.07  | 8.00 | 3.83      | -0.21 | 2.62       | not sig. |

**Appendix E – HOQ Plumbing System Retrofit Relationship Data, Technical Importance Calculations, and Data Analysis Calculations**

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**Table 32 – Plumbing System Technical Importance Calculations: Results for each Individual Participant**

| Potential Stakeholder Requirements: |                                     | Plumbing System Retrofit - Summary of Technical Importance |          |          |          |                   |               |               |                 |               |                 |              |                |                      |                        |                      |                      |                         |                             |                              |                             |                   |                       |               |                   |               |                   |               |               |               |                          |   |
|-------------------------------------|-------------------------------------|--|----------|----------|----------|-------------------|---------------|---------------|-----------------|---------------|-----------------|--------------|----------------|----------------------|------------------------|----------------------|----------------------|-------------------------|-----------------------------|------------------------------|-----------------------------|-------------------|-----------------------|---------------|-------------------|---------------|-------------------|---------------|---------------|---------------|--------------------------|---|
|                                     |                                     | Tenant 4   | Tenant 3 | Tenant 2 | Tenant 1 | Tenant (Director) | Tenant (APWO) | Owner 1 (UEM) | Owner 2 (UEM-J) | Owner 3 (UEM) | Owner 4 (UEM-T) | Owner 5 (AM) | Owner 5 (AM-A) | Facility Mgr. 1 (CM) | Facility Mgr. 2 (CM-J) | Facility Mgr. 3 (EE) | Facility Mgr. 4 (ME) | Facility Mgr. 5 (Maint) | Facility Mgr. 6 (Maint - R) | Facility Mgr. 7 (Maint - K1) | Facility Mgr. 8 (Maint - K) | Designer (ME - B) | Designer 2 (ME - Byd) | Designer (ME) | Designer (ME - T) | Designer (PM) | Designer (PM - A) | Designer (CE) | Designer (TL) | Environmental | Environmental 2 (EV - S) |   |
| 1                                   | Reduce energy costs                 | 12   | 5        | 5        | 4        | 25                | 5             | 25            | 25              | 5             | 15              | 15           | 15             | 15                   | 15                     | 5                    | 25                   | 15                      | 15                          | 5                            | 12                          | 15                | 5                     | 5             | 15                | 5             | 0                 | 15            | 5             | 5             | 5                        |   |
| 2                                   | Increase return on investment       | 12   | 15       | 5        | 5        | 20                | 25            | 25            | 5               | 15            | 15              | 15           | 15             | 25                   | 4                      | 20                   | 15                   | 15                      | 5                           | 5                            | 25                          | 5                 | 5                     | 5             | 15                | 4             | 4                 | 4             | 4             | 4             |                          |   |
| 3                                   | Minimize environmental impact       | 15   | 20       | 27       | 12       | 9                 | 12            | 15            | 20              | 9             | 9               | 36           | 36             | 9                    | 25                     | 12                   | 9                    | 20                      | 20                          | 3                            | 3                           | 4                 | 2                     | 20            | 4                 | 4             | 3                 | 15            | 12            |               |                          |   |
| 4                                   | Improve your organization's image   | 4  | 12       | 9        | 3        | 3                 | 2             | 3             | 3               | 3             | 5               | 5            | 9              | 3                    | 3                      | 15                   | 9                    | 3                       | 10                          | 9                            | 2                           | 2                 | 2                     | 12            | 0                 | 6             | 9                 | 3             | 3             |               |                          |   |
| 5                                   | Improve occupant comfort            | 9  | 12       | 4        | 5        | 5                 | 9             | 3             | 4               | 4             | 3               | 4            | 12             | 0                    | 9                      | 4                    | 12                   | 4                       | 12                          | 4                            | 9                           | 0                 | 2                     | 3             | 0                 | 12            | 0                 | 12            | 3             | 3             |                          |   |
| 6                                   | Increase energy efficiency          | 12   | 5        | 5        | 5        | 4                 | 25            | 5             | 5               | 5             | 15              | 5            | 5              | 5                    | 45                     | 45                   | 15                   | 15                      | 36                          | 12                           | 4                           | 3                 | 9                     | 5             | 4                 | 12            | 4                 | 4             | 4             |               |                          |   |
| 7                                   | Increase carbon neutrality          | 3  | 0        | 4        | 0        | 0                 | 1             | 2             | 2               | 1             | 3               | 9            | 0              | 2                    | 3                      | 15                   | 3                    | 9                       | 1                           | 9                            | 0                           | 1                 | 1                     | 0             | 0                 | 0             | 0                 | 0             | 0             | 0             |                          |   |
| 8                                   | Achieve lower total ownership costs | 12   | 15       | 12       | 5        | 5                 | 12            | 25            | 20              | 4             | 15              | 25           | 5              | 45                   | 25                     | 20                   | 12                   | 20                      | 15                          | 12                           | 5                           | 4                 | 5                     | 3             | 15                | 0             | 15                | 15            | 25            |               |                          |   |
| 9                                   | Meet regulatory requirements        | 20   | 9        | 10       | 4        | 5                 | 20            | 15            | 3               | 3             | 15              | 20           | 25             | 45                   | 45                     | 45                   | 20                   | 15                      | 15                          | 20                           | 3                           | 12                | 12                    | 3             | 9                 | 5             | 0                 | 0             | 25            | 25            |                          |   |
| 10                                  | Comply with policy or legislation   | 20   | 15       | 15       | 5        | 5                 | 20            | 27            | 27              | 15            | 15              | 25           | 25             | 25                   | 15                     | 45                   | 45                   | 25                      | 15                          | 25                           | 4                           | 4                 | 3                     | 3             | 15                | 5             | 4                 | 25            | 25            |               |                          |   |
| 11                                  | Improve aesthetic quality of site   | 0  | 9        | 0        | 0        | 0                 | 2             | 2             | 0               | 2             | 3               | 0            | 9              | 6                    | 2                      | 2                    | 2                    | 2                       | 3                           | 3                            | 2                           | 2                 | 2                     | 0             | 9                 | 0             | 1                 | 3             | 0             | 0             |                          |   |
| 12                                  | Improve occupant productivity       | 12   | 15       | 9        | 5        | 5                 | 2             | 3             | 3               | 4             | 3               | 9            | 9              | 15                   | 4                      | 15                   | 12                   | 12                      | 20                          | 0                            | 0                           | 0                 | 0                     | 0             | 12                | 0             | 3                 | 3             | 4             | 4             |                          |   |
| 13                                  | Reduce chance of opposition         | 20   | 6        | 2        | 9        | 9                 | 2             | 1             | 0               | 0             | 3               | 9            | 3              | 9                    | 3                      | 4                    | 12                   | 3                       | 3                           | 15                           | 12                          | 0                 | 3                     | 2             | 0                 | 3             | 0                 | 0             | 0             | 12            | 12                       |   |
| 14                                  | Increase property value             | 12   | 9        | 6        | 6        | 18                | 1             | 0             | 0               | 3             | 9               | 25           | 3              | 3                    | 2                      | 9                    | 2                    | 3                       | 15                          | 27                           | 0                           | 3                 | 2                     | 0             | 9                 | 0             | 3                 | 3             | 1             | 2             |                          |   |
| 15                                  | Reduce energy consumption           | 12   | 0        | 5        | 5        | 4                 | 25            | 5             | 25              | 25            | 15              | 25           | 15             | 15                   | 5                      | 25                   | 15                   | 15                      | 25                          | 9                            | 12                          | 4                 | 3                     | 0             | 0                 | 9             | 15                | 4             | 4             |               |                          |   |
| 16                                  | Provide a secure energy supply      | 9  | 4        | 12       | 0        | 5                 | 20            | 5             | 5               | 2             | 3               | 2            | 0              | 0                    | 2                      | 3                    | 3                    | 2                       | 12                          | 15                           | 3                           | 3                 | 0                     | 0             | 4                 | 0             | 0                 | 0             | 4             | 4             |                          |   |
| 17                                  | Facilitate renewable energy         | 12   | 0        | 4        | 6        | 10                | 9             | 3             | 6               | 6             | 3               | 2            | 3              | 0                    | 0                      | 5                    | 10                   | 15                      | 6                           | 6                            | 3                           | 9                 | 6                     | 2             | 0                 | 0             | 0                 | 0             | 4             | 3             |                          |   |
| 18                                  | Lower project capital costs         | 3  | 0        | 0        | 0        | 25                | 20            | 12            | 12              | 4             | 4               | 0            | 15             | 0                    | 4                      | 0                    | 0                    | 12                      | 0                           | 20                           | 4                           | 12                | 12                    | 4             | 0                 | 0             | 0                 | 0             | 0             | 4             | 3                        |   |
| 19                                  | Reduce costs of carbon offset       | 9  | 0        | 0        | 0        | 4                 | 1             | 1             | 0               | 0             | 2               | 0            | 6              | 1                    | 2                      | 6                    | 15                   | 0                       | 15                          | 20                           | 3                           | 3                 | 0                     | 0             | 0                 | 0             | 0                 | 1             | 2             | 0             | 0                        |   |
| 20                                  | Achieve higher rental rates         | 20   | 3        | 6        | 0        | 9                 | 1             | 0             | 0               | 3             | 3               | 0            | 12             | 0                    | 0                      | 3                    | 2                    | 1                       | 0                           | 6                            | 3                           | 9                 | 0                     | 0             | 3                 | 0             | 2                 | 2             | 9             | 12            |                          |   |
| 21                                  | Achieve higher occupancy rates      | 12   | 12       | 3        | 3        | 9                 | 1             | 3             | 2               | 2             | 3               | 3            | 15             | 3                    | 0                      | 3                    | 9                    | 2                       | 2                           | 2                            | 0                           | 9                 | 6                     | 0             | 6                 | 0             | 2                 | 2             | 9             | 12            |                          |   |
| 22                                  | Avoid costs due to opposition       | 20   | 10       | 9        | 2        | 4                 | 2             | 0             | 0               | 6             | 9               | 3            | 0              | 0                    | 0                      | 12                   | 12                   | 3                       | 3                           | 9                            | 0                           | 0                 | 0                     | 0             | 5                 | 0             | 2                 | 2             | 9             | 12            |                          |   |
| 23                                  | Gain the public's trust             | 12   | 12       | 12       | 4        | 4                 | 0             | 3             | 0               | 0             | 3               | 9            | 0              | 0                    | 0                      | 3                    | 15                   | 4                       | 2                           | 9                            | 9                           | 0                 | 0                     | 0             | 12                | 0             | 3                 | 3             | 12            | 4             |                          |   |
| 24                                  | Decrease outages / interruptions    | 20   | 4        | 25       | 45       | 45                | 20            | 4             | 4               | 3             | 20              | 15           | 45             | 45                   | 3                      | 4                    | 5                    | 4                       | 3                           | 3                            | 2                           | 2                 | 0                     | 4             | 0                 | 0             | 0                 | 0             | 12            | 12            |                          |   |
| 25                                  | Attract and retain employees        | 12   | 12       | 12       | 3        | 3                 | 1             | 3             | 15              | 15            | 3               | 4            | 4              | 0                    | 20                     | 5                    | 12                   | 12                      | 6                           | 15                           | 0                           | 2                 | 2                     | 0             | 12                | 0             | 6                 | 6             | 0             | 0             |                          |   |
| 26                                  | Improve occupant attendance         | 12   | 25       | 12       | 25       | 25                | 2             | 2             | 2               | 3             | 4               | 4            | 0              | 6                    | 15                     | 15                   | 2                    | 2                       | 9                           | 9                            | 0                           | 2                 | 2                     | 0             | 15                | 0             | 3                 | 3             | 0             | 0             |                          |   |
| 27                                  | Improve occupant health             | 20   | 4        | 12       | 25       | 25                | 12            | 9             | 3               | 2             | 6               | 12           | 12             | 0                    | 20                     | 6                    | 15                   | 2                       | 3                           | 3                            | 9                           | 9                 | 3                     | 3             | 4                 | 0             | 9                 | 6             | 3             | 3             |                          |   |
| 28                                  | Improve corporate reporting results | 9  | 15       | 25       | 20       | 15                | 20            | 4             | 1               | 4             | 2               | 12           | 4              | 20                   | 20                     | 6                    | 12                   | 5                       | 3                           | 15                           | 15                          | 2                 | 2                     | 4             | 3                 | 15            | 0                 | 12            | 9             | 45            | 5                        |   |
| 29                                  | Diversify investment portfolios     | 6  | 9        | 2        | 0        | 9                 | 1             | 0             | 0               | 0             | 0               | 0            | 0              | 0                    | 0                      | 6                    | 12                   | 2                       | 2                           | 12                           | 12                          | 0                 | 2                     | 1             | 0                 | 9             | 0                 | 1             | 1             | 0             | 0                        |   |
| 30                                  | Leverage business platforms         | 4  | 15       | 15       | 12       | 3                 | 4             | 1             | 1               | 0             | 0               | 0            | 3              | 0                    | 0                      | 12                   | 12                   | 3                       | 3                           | 4                            | 4                           | 4                 | 4                     | 2             | 0                 | 0             | 15                | 0             | 1             | 1             | 4                        | 3 |

**Table 33 – Plumbing System Technical Importance Rating Summary and Data Analysis Calculations, by Stakeholder Group**

| Potential Stakeholder Requirements: |                                     | Plumbing System Retrofits - Technical Importance |           |          |         |           |          |               |           |          |           |           |          |              |           |          |               |           |          |
|-------------------------------------|-------------------------------------|--|-----------|----------|---------|-----------|----------|---------------|-----------|----------|-----------|-----------|----------|--------------|-----------|----------|---------------|-----------|----------|
|                                     |                                     | Tenant   |           |          | Owner   |           |          | Facility Mgr. |           |          | Designers |           |          | Environmntl. |           |          | Weighted Avg. |           |          |
|                                     |                                     | Average  | Std. Dev. | Variance | Average | Std. Dev. | Variance | Average       | Std. Dev. | Variance | Average   | Std. Dev. | Variance | Average      | Std. Dev. | Variance | Average       | Std. Dev. | Variance |
| 1                                   | Reduce energy costs                 | 9.33   | 7.5       | 56       | 15      | 8.2       | 67       | 13.4          | 6         | 36       | 9.29      | 4.9       | 24       | 5            | 0         | 0        | 10.4          | 3.51      | 12.3     |
| 2                                   | Increase return on investment       | 10.3   | 5.8       | 34       | 15      | 8.2       | 67       | 15.5          | 7.4       | 56       | 6.14      | 3.6       | 13       | 4            | 0         | 0        | 10.2          | 4.61      | 21.2     |
| 3                                   | Minimize environmental impact       | 15.8   | 6         | 36       | 12.3    | 4.1       | 17       | 20.9          | 10        | 105      | 5.57      | 5.9       | 35       | 13.5         | 1.5       | 2.3      | 13.6          | 4.98      | 24.8     |
| 4                                   | Improve your organization's image   | 5.5  | 3.7       | 14       | 3.67    | 0.9       | 0.9      | 7.63          | 4         | 16       | 5         | 3.8       | 15       | 3            | 0         | 0        | 4.96          | 1.61      | 2.58     |
| 5                                   | Improve occupant comfort            | 7.33   | 2.9       | 8.2      | 5       | 3.2       | 10       | 6.75          | 4.1       | 17       | 5.86      | 5.4       | 29       | 3            | 0         | 0        | 5.59          | 1.52      | 2.3      |
| 6                                   | Increase energy efficiency          | 9.33   | 7.5       | 56       | 6.67    | 3.7       | 14       | 22.6          | 16        | 247      | 8.14      | 3.8       | 14       | 4            | 0         | 0        | 10.2          | 6.49      | 42.1     |
| 7                                   | Increase carbon neutrality          | 1.33   | 1.6       | 2.6      | 3       | 2.8       | 7.7      | 5.25          | 4.9       | 24       | 0.29      | 0.5       | 0.2      | 0            | 0         | 0        | 1.97          | 1.95      | 3.79     |
| 8                                   | Achieve lower total ownership costs | 10.2   | 3.8       | 14       | 15.5    | 8.8       | 78       | 19.3          | 11        | 128      | 8.86      | 5.4       | 29       | 20           | 5         | 25       | 14.8          | 4.56      | 20.8     |
| 9                                   | Meet regulatory requirements        | 11.3   | 6.5       | 42       | 13.5    | 8.2       | 67       | 31.3          | 14        | 192      | 5.57      | 4.9       | 24       | 25           | 0         | 0        | 17.3          | 9.4       | 88.3     |
| 10                                  | Comply with policy or legislation   | 13.3   | 6.2       | 39       | 22.3    | 5.2       | 28       | 27.5          | 11        | 119      | 5.29      | 4         | 16       | 25           | 0         | 0        | 18.7          | 8.23      | 67.8     |
| 11                                  | Improve aesthetic quality of site   | 1.83   | 3.3       | 11       | 1.17    | 1.2       | 1.5      | 3.63          | 2.4       | 5.7      | 2.43      | 2.9       | 8.2      | 0            | 0         | 0        | 1.81          | 1.21      | 1.47     |
| 12                                  | Improve occupant productivity       | 8  | 4.5       | 20       | 4.33    | 2.1       | 4.6      | 12.4          | 4.4       | 19       | 2.57      | 4.1       | 17       | 4            | 0         | 0        | 6.26          | 3.55      | 12.6     |
| 13                                  | Reduce chance of opposition         | 8  | 6.1       | 37       | 2.67    | 3.1       | 9.6      | 7.63          | 4.6       | 21       | 1.14      | 1.4       | 1.8      | 12           | 0         | 0        | 6.29          | 3.92      | 15.4     |
| 14                                  | Increase property value             | 8.67   | 5.3       | 29       | 6.67    | 8.7       | 76       | 8             | 8.4       | 70       | 2.86      | 2.8       | 7.8      | 1.5          | 0.5       | 0.3      | 5.54          | 2.85      | 8.12     |
| 15                                  | Reduce energy consumption           | 8.5  | 8.2       | 67       | 16.7    | 9         | 81       | 16.3          | 6         | 36       | 7.43      | 4.9       | 24       | 4            | 0         | 0        | 10.6          | 5.03      | 25.4     |
| 16                                  | Provide a secure energy supply      | 8.33   | 6.4       | 42       | 3.17    | 1.3       | 1.8      | 4.63          | 5.3       | 28       | 1.43      | 1.7       | 2.8      | 4            | 0         | 0        | 4.31          | 2.28      | 5.2      |
| 17                                  | Facilitate renewable energy         | 6.83   | 4         | 16       | 3.83    | 1.6       | 2.5      | 5.88          | 4.6       | 21       | 2.86      | 3.2       | 10       | 3.5          | 0.5       | 0.3      | 4.58          | 1.51      | 2.29     |
| 18                                  | Lower project capital costs         | 8  | 10        | 108      | 7.83    | 5.4       | 29       | 4.5           | 7.1       | 50       | 11        | 8.4       | 71       | 12           | 0         | 0        | 8.67          | 2.65      | 7.01     |
| 19                                  | Reduce costs of carbon offset       | 2.33   | 3.3       | 11       | 1.5     | 2.1       | 4.6      | 7.38          | 7.5       | 57       | 1.29      | 1.3       | 1.6      | 0            | 0         | 0        | 2.5           | 2.55      | 6.5      |
| 20                                  | Achieve higher rental rates         | 6.5  | 6.8       | 46       | 3       | 4.2       | 18       | 1.63          | 1.9       | 3.7      | 2.71      | 2.8       | 7.9      | 10.5         | 1.5       | 2.3      | 4.87          | 3.26      | 10.6     |
| 21                                  | Achieve higher occupancy rates      | 6.67   | 4.5       | 20       | 4.67    | 4.6       | 22       | 2.88          | 2.5       | 6.1      | 3.57      | 3.2       | 10       | 10.5         | 1.5       | 2.3      | 5.66          | 2.74      | 7.51     |
| 22                                  | Avoid costs due to opposition       | 7.83   | 6.3       | 39       | 4       | 3.3       | 11       | 6             | 4.7       | 23       | 1.29      | 1.7       | 3.1      | 10.5         | 1.5       | 2.3      | 5.92          | 3.16      | 9.96     |
| 23                                  | Gain the public's trust             | 7.33   | 4.9       | 24       | 2.5     | 3.2       | 10       | 5.25          | 4.9       | 24       | 2.57      | 4.1       | 17       | 8            | 4         | 16       | 5.13          | 2.31      | 5.31     |
| 24                                  | Decrease outages / interruptions    | 26.5   | 15        | 213      | 8.17    | 6.8       | 46       | 14            | 18        | 321      | 1.14      | 1.5       | 2.1      | 12           | 0         | 0        | 12.4          | 8.32      | 69.2     |
| 25                                  | Attract and retain employees        | 7.17   | 4.9       | 24       | 7.33    | 5.4       | 30       | 9.38          | 6.1       | 37       | 4         | 4         | 16       | 0            | 0         | 0        | 5.58          | 3.27      | 10.7     |
| 26                                  | Improve occupant attendance         | 16.8   | 8.8       | 78       | 3       | 0.8       | 0.7      | 7.25          | 5.4       | 29       | 3.57      | 4.8       | 23       | 0            | 0         | 0        | 6.13          | 5.83      | 33.9     |
| 27                                  | Improve occupant health             | 16.3   | 7.7       | 59       | 7.33    | 4         | 16       | 6.5           | 6.7       | 44       | 6.14      | 2.6       | 7        | 3            | 0         | 0        | 7.86          | 4.48      | 20.1     |
| 28                                  | Improve corporate reporting results | 17.3   | 5.1       | 26       | 4.5     | 3.5       | 13       | 12            | 6.2       | 39       | 6.71      | 4.9       | 24       | 25           | 20        | 400      | 13.1          | 7.42      | 55.1     |
| 29                                  | Diversify investment portfolios     | 4.5  | 3.7       | 14       | 0       | 0         | 0        | 5.75          | 5.1       | 26       | 2         | 2.9       | 8.6      | 0            | 0         | 0        | 2.45          | 2.34      | 5.46     |
| 30                                  | Leverage business platforms         | 8.83   | 5.3       | 28       | 0.83    | 1.1       | 1.1      | 4.75          | 4.4       | 20       | 3.29      | 4.9       | 24       | 3.5          | 0.5       | 0.3      | 4.24          | 2.62      | 6.88     |
| S                                   | Minimum                             | 1.3  |           |          | 0.0     |           |          | 1.6           |           |          | 0.3       |           |          | 0.0          |           |          | 1.8           |           |          |
| T                                   | 1st Quartile (lower 25%)            | 6.9  |           |          | 3.0     |           |          | 5.4           |           |          | 2.5       |           |          | 3.0          |           |          | 4.9           |           |          |
| A                                   | Median                              | 8.2  |           |          | 4.6     |           |          | 7.5           |           |          | 3.6       |           |          | 4.0          |           |          | 6.0           |           |          |
| T                                   | 3rd Quartile (upper 25%)            | 10.3   |           |          | 8.1     |           |          | 13.8          |           |          | 6.1       |           |          | 11.6         |           |          | 10.5          |           |          |
| S                                   | Maximum                             | 26.5   |           |          | 22.3    |           |          | 31.3          |           |          | 11.0      |           |          | 25.0         |           |          | 18.7          |           |          |

**Appendix F – HOQ Building Envelope Retrofit Relationship Data, Technical Importance Calculations, and Data Analysis Calculations**

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**Table 34 – Building Envelope Retrofits, Relationship Rating Survey Data: HOQ Survey Individual Participant Responses**

| Potential Stakeholder Requirements: |                                     | Building Envelope Retrofits Vs. Stakeholder Requirements - Relationship Rating Data |          |          |          |                   |               |               |                 |               |                 |              |                |                      |                        |                      |                      |                         |                             |                              |                             |                   |                       |               |                 |               |                   |               |               |               |                          |   |   |   |   |   |   |   |
|-------------------------------------|-------------------------------------|---|----------|----------|----------|-------------------|---------------|---------------|-----------------|---------------|-----------------|--------------|----------------|----------------------|------------------------|----------------------|----------------------|-------------------------|-----------------------------|------------------------------|-----------------------------|-------------------|-----------------------|---------------|-----------------|---------------|-------------------|---------------|---------------|---------------|--------------------------|---|---|---|---|---|---|---|
|                                     |                                     | Tenant 4  | Tenant 3 | Tenant 2 | Tenant 1 | Tenant (Director) | Tenant (APWO) | Owner 1 (UEM) | Owner 2 (UEM-J) | Owner 3 (UEM) | Owner 4 (UEM-T) | Owner 5 (AM) | Owner 5 (AM-A) | Facility Mgr. 1 (CM) | Facility Mgr. 2 (CM-J) | Facility Mgr. 3 (EE) | Facility Mgr. 4 (ME) | Facility Mgr. 5 (Maint) | Facility Mgr. 6 (Maint - R) | Facility Mgr. 7 (Maint - K1) | Facility Mgr. 8 (Maint - K) | Designer (ME - B) | Designer 2 (ME - Byd) | Designer (ME) | Designer (ME-T) | Designer (PM) | Designer (PM - A) | Designer (CE) | Designer (TL) | Environmental | Environmental 2 (EV - S) |   |   |   |   |   |   |   |
| 1                                   | Reduce energy costs                 | 5   | 5        | 3        | 3        | 3                 | 9             | 1             | 1               | 1             | 1               | 5            | 5              | 9                    | 9                      | 5                    | 5                    | 5                       | 5                           | 5                            | 5                           | 3                 | 9                     | 5             | 5               | 9             | 5                 | 5             | 9             | 5             | 5                        | 5 | 5 | 5 | 5 |   |   |   |
| 2                                   | Increase return on investment       | 5   | 3        | 3        | 0        | 1                 | 5             | 1             | 0               | 0             | 1               | 3            | 5              | 9                    | 9                      | 3                    | 3                    | 5                       | 3                           | 3                            | 3                           | 3                 | 9                     | 9             | 3               | 3             | 1                 | 5             | 5             | 5             | 5                        | 5 | 5 | 5 | 5 |   |   |   |
| 3                                   | Minimize environmental impact       | 5   | 3        | 3        | 5        | 1                 | 5             | 1             | 1               | 1             | 1               | 3            | 3              | 9                    | 9                      | 5                    | 5                    | 5                       | 5                           | 1                            | 5                           | 5                 | 1                     | 9             | 9               | 1             | 3                 | 1             | 1             | 5             | 1                        | 1 | 5 | 1 | 1 |   |   |   |
| 4                                   | Improve your organization's image   | 5   | 5        | 3        | 5        | 1                 | 1             | 1             | 1               | 1             | 3               | 9            | 9              | 9                    | 9                      | 9                    | 9                    | 9                       | 5                           | 3                            | 9                           | 5                 | 5                     | 5             | 3               | 3             | 5                 | 3             | 1             | 1             | 5                        | 3 | 1 | 1 | 5 | 3 |   |   |
| 5                                   | Improve occupant comfort            | 5   | 5        | 5        | 5        | 1                 | 3             | 9             | 9               | 1             | 1               | 9            | 9              | 5                    | 5                      | 5                    | 5                    | 5                       | 5                           | 3                            | 3                           | 1                 | 9                     | 9             | 3               | 3             | 5                 | 3             | 3             | 5             | 3                        | 5 | 3 | 5 | 5 | 5 |   |   |
| 6                                   | Increase energy efficiency          | 5   | 3        | 5        | 5        | 1                 | 5             | 3             | 3               | 3             | 3               | 5            | 5              | 9                    | 9                      | 9                    | 9                    | 9                       | 5                           | 5                            | 5                           | 5                 | 9                     | 9             | 9               | 9             | 3                 | 3             | 9             | 9             | 3                        | 3 | 9 | 5 | 5 | 5 |   |   |
| 7                                   | Increase carbon neutrality          | 1   | 5        | 5        | 3        | 1                 | 1             | 3             | 1               | 1             | 3               | 5            | 5              | 9                    | 9                      | 5                    | 5                    | 5                       | 5                           | 5                            | 3                           | 3                 | 1                     | 5             | 5               | 1             | 5                 | 1             | 1             | 1             | 5                        | 1 | 1 | 5 | 5 | 5 |   |   |
| 8                                   | Achieve lower total ownership costs | 5   | 3        | 5        | 5        | 1                 | 3             | 3             | 1               | 1             | 3               | 9            | 9              | 9                    | 9                      | 5                    | 5                    | 5                       | 5                           | 5                            | 3                           | 3                 | 5                     | 5             | 3               | 3             | 5                 | 5             | 3             | 3             | 1                        | 1 | 9 | 9 | 5 | 5 |   |   |
| 9                                   | Meet regulatory requirements        | 3   | 3        | 3        | 1        | 1                 | 5             | 1             | 0               | 0             | 1               | 5            | 5              | 3                    | 3                      | 9                    | 9                    | 3                       | 3                           | 3                            | 1                           | 5                 | 5                     | 1             | 3               | 1             | 1                 | 3             | 1             | 1             | 0                        | 3 | 5 | 5 | 5 | 5 |   |   |
| 10                                  | Comply with policy or legislation   | 5   | 3        | 5        | 3        | 3                 | 5             | 3             | 3               | 1             | 1               | 5            | 5              | 3                    | 3                      | 9                    | 9                    | 5                       | 3                           | 3                            | 1                           | 3                 | 3                     | 1             | 1               | 3             | 1                 | 1             | 3             | 1             | 5                        | 5 | 5 | 5 | 5 | 3 |   |   |
| 11                                  | Improve aesthetic quality of site   | 9   | 9        | 5        | 5        | 5                 | 3             | 0             | 0               | 9             | 9               | 9            | 9              | 9                    | 9                      | 9                    | 9                    | 9                       | 5                           | 9                            | 9                           | 3                 | 9                     | 9             | 3               | 9             | 3                 | 9             | 3             | 3             | 5                        | 5 | 5 | 5 | 5 | 5 |   |   |
| 12                                  | Improve occupant productivity       | 3   | 5        | 5        | 3        | 0                 | 3             | 5             | 5               | 1             | 1               | 3            | 3              | 5                    | 5                      | 5                    | 5                    | 5                       | 5                           | 1                            | 3                           | 1                 | 1                     | 3             | 3               | 1             | 5                 | 1             | 1             | 3             | 3                        | 1 | 1 | 3 | 3 | 1 | 1 |   |
| 13                                  | Reduce chance of opposition         | 9   | 5        | 5        | 3        | 3                 | 3             | 1             | 1               | 3             | 5               | 3            | 3              | 3                    | 3                      | 5                    | 5                    | 3                       | 3                           | 5                            | 3                           | 1                 | 3                     | 3             | 1               | 5             | 0                 | 1             | 0             | 5             | 5                        | 5 | 5 | 5 | 5 | 5 |   |   |
| 14                                  | Increase property value             | 5   | 5        | 5        | 9        | 9                 | 1             | 5             | 1               | 1             | 5               | 9            | 9              | 5                    | 5                      | 9                    | 9                    | 3                       | 3                           | 5                            | 5                           | 9                 | 9                     | 3             | 3               | 5             | 1                 | 5             | 5             | 3             | 3                        | 3 | 5 | 5 | 5 | 5 | 3 |   |
| 15                                  | Reduce energy consumption           | 5   | 9        | 5        | 5        | 3                 | 5             | 1             | 1               | 1             | 1               | 9            | 9              | 9                    | 9                      | 5                    | 5                    | 5                       | 5                           | 5                            | 3                           | 5                 | 5                     | 3             | 3               | 9             | 3                 | 9             | 3             | 3             | 5                        | 5 | 5 | 5 | 5 | 5 |   |   |
| 16                                  | Provide a secure energy supply      | 3   | 5        | 3        | 5        | 5                 | 5             | 1             | 1               | 1             | 1               | 1            | 1              | 0                    | 0                      | 1                    | 1                    | 3                       | 1                           | 1                            | 1                           | 0                 | 5                     | 5             | 1               | 5             | 0                 | 5             | 0             | 1             | 1                        | 1 | 1 | 1 | 1 | 1 | 1 |   |
| 17                                  | Facilitate renewable energy         | 3   | 1        | 1        | 0        | 9                 | 3             | 5             | 5               | 1             | 1               | 3            | 1              | 5                    | 5                      | 1                    | 1                    | 5                       | 9                           | 9                            | 0                           | 3                 | 3                     | 0             | 1               | 0             | 0                 | 5             | 5             | 3             | 3                        | 1 | 1 | 0 | 0 | 5 | 3 |   |
| 18                                  | Lower project capital costs         | 0   | 0        | 0        | 5        | 5                 | 9             | 9             | 1               | 1             | 0               | 9            | 0              | 5                    | 0                      | 0                    | 0                    | 3                       | 1                           | 5                            | 1                           | 5                 | 1                     | 9             | 9               | 1             | 0                 | 0             | 9             | 9             | 3                        | 3 | 3 | 3 | 3 | 3 |   |   |
| 19                                  | Reduce costs of carbon offset       | 3   | 3        | 3        | 3        | 9                 | 1             | 1             | 0               | 0             | 1               | 5            | 5              | 9                    | 9                      | 5                    | 5                    | 3                       | 1                           | 3                            | 3                           | 3                 | 1                     | 1             | 3               | 1             | 1                 | 3             | 1             | 1             | 3                        | 3 | 1 | 1 | 3 | 3 | 1 |   |
| 20                                  | Achieve higher rental rates         | 5   | 5        | 5        | 0        | 9                 | 1             | 3             | 1               | 1             | 3               | 5            | 5              | 0                    | 3                      | 5                    | 5                    | 3                       | 3                           | 1                            | 3                           | 9                 | 9                     | 0             | 0               | 5             | 0                 | 3             | 3             | 5             | 5                        | 5 | 5 | 5 | 5 | 5 | 5 |   |
| 21                                  | Achieve higher occupancy rates      | 3   | 3        | 5        | 3        | 9                 | 1             | 1             | 5               | 5             | 1               | 5            | 5              | 0                    | 0                      | 3                    | 3                    | 3                       | 3                           | 3                            | 3                           | 1                 | 9                     | 9             | 1               | 3             | 0                 | 1             | 3             | 0             | 1                        | 3 | 5 | 5 | 5 | 5 |   |   |
| 22                                  | Avoid costs due to opposition       | 9   | 3        | 5        | 1        | 1                 | 1             | 1             | 1               | 1             | 1               | 5            | 3              | 0                    | 0                      | 5                    | 5                    | 5                       | 3                           | 3                            | 1                           | 1                 | 3                     | 3             | 1               | 3             | 0                 | 1             | 1             | 5             | 5                        | 5 | 5 | 5 | 5 | 5 |   |   |
| 23                                  | Gain the public's trust             | 5   | 5        | 5        | 3        | 1                 | 1             | 0             | 0               | 1             | 1               | 5            | 3              | 0                    | 0                      | 5                    | 5                    | 3                       | 3                           | 1                            | 0                           | 3                 | 3                     | 0             | 5               | 1             | 0                 | 3             | 3             | 1             | 1                        | 0 | 3 | 3 | 1 | 1 | 5 |   |
| 24                                  | Decrease outages / interruptions    | 1   | 0        | 0        | 0        | 0                 | 5             | 1             | 1               | 1             | 1               | 3            | 3              | 5                    | 5                      | 1                    | 1                    | 1                       | 1                           | 0                            | 0                           | 3                 | 3                     | 0             | 0               | 0             | 0                 | 0             | 0             | 1             | 1                        | 0 | 0 | 1 | 1 | 0 | 0 |   |
| 25                                  | Attract and retain employees        | 5   | 5        | 5        | 3        | 1                 | 1             | 3             | 5               | 5             | 3               | 3            | 9              | 9                    | 3                      | 3                    | 5                    | 5                       | 3                           | 3                            | 5                           | 3                 | 5                     | 5             | 3               | 5             | 1                 | 3             | 3             | 1             | 1                        | 3 | 3 | 1 | 1 | 1 | 1 |   |
| 26                                  | Improve occupant attendance         | 5   | 3        | 5        | 5        | 0                 | 1             | 1             | 5               | 5             | 1               | 3            | 3              | 3                    | 3                      | 5                    | 5                    | 1                       | 1                           | 3                            | 5                           | 1                 | 1                     | 1             | 1               | 1             | 1                 | 3             | 1             | 1             | 1                        | 1 | 1 | 1 | 1 | 1 | 0 |   |
| 27                                  | Improve occupant health             | 3   | 3        | 5        | 5        | 3                 | 3             | 1             | 3               | 3             | 1               | 3            | 3              | 3                    | 3                      | 3                    | 3                    | 3                       | 0                           | 3                            | 3                           | 1                 | 5                     | 5             | 1               | 3             | 1                 | 1             | 1             | 1             | 1                        | 1 | 1 | 1 | 1 | 1 | 1 |   |
| 28                                  | Improve corporate reporting results | 1   | 9        | 5        | 5        | 5                 | 5             | 1             | 1               | 1             | 1               | 3            | 3              | 3                    | 3                      | 3                    | 3                    | 3                       | 5                           | 3                            | 3                           | 1                 | 5                     | 5             | 1               | 5             | 1                 | 9             | 1             | 3             | 3                        | 5 | 1 | 1 | 1 | 1 | 1 |   |
| 29                                  | Diversify investment portfolios     | 1   | 3        | 1        | 0        | 9                 | 1             | 0             | 0               | 1             | 1               | 3            | 3              | 0                    | 0                      | 3                    | 3                    | 1                       | 1                           | 3                            | 3                           | 1                 | 3                     | 3             | 3               | 0             | 0                 | 3             | 0             | 0             | 1                        | 0 | 3 | 0 | 0 | 1 | 0 | 3 |
| 30                                  | Leverage business platforms         | 3   | 3        | 3        | 5        | 9                 | 1             | 0             | 0               | 1             | 1               | 1            | 3              | 0                    | 0                      | 3                    | 3                    | 5                       | 5                           | 1                            | 1                           | 1                 | 1                     | 1             | 1               | 1             | 1                 | 0             | 0             | 3             | 0                        | 1 | 1 | 1 | 1 | 1 | 1 |   |

**Table 35 – Building Envelope Technical Importance Calculations: Results for each Individual Participant**

| Potential Stakeholder Requirements:    | Building Envelope Retrofits - Summary of Technical Importance |          |          |          |                   |               |               |                 |               |                 |              |                |                      |                        |                      |                      |                         |                             |                              |                             |                   |                       |               |                 |               |                   |               |               |               |                          |
|--|---|----------|----------|----------|-------------------|---------------|---------------|-----------------|---------------|-----------------|--------------|----------------|----------------------|------------------------|----------------------|----------------------|-------------------------|-----------------------------|------------------------------|-----------------------------|-------------------|-----------------------|---------------|-----------------|---------------|-------------------|---------------|---------------|---------------|--------------------------|
|  | Tenant 4  | Tenant 3 | Tenant 2 | Tenant 1 | Tenant (Director) | Tenant (APWO) | Owner 1 (UEM) | Owner 2 (UEM-J) | Owner 3 (UEM) | Owner 4 (UEM-T) | Owner 5 (AM) | Owner 5 (AM-A) | Facility Mgr. 1 (CM) | Facility Mgr. 2 (CM-J) | Facility Mgr. 3 (EE) | Facility Mgr. 4 (ME) | Facility Mgr. 5 (Maint) | Facility Mgr. 6 (Maint - R) | Facility Mgr. 7 (Maint - K1) | Facility Mgr. 8 (Maint - K) | Designer (ME - B) | Designer 2 (ME - Byd) | Designer (ME) | Designer (ME-T) | Designer (PM) | Designer (PM - A) | Designer (CE) | Designer (TI) | Environmental | Environmental 2 (EV - S) |
| 1 Reduce energy costs                  | 20  | 25       | 15       | 15       | 12                | 45            | 5             | 5               | 5             | 5               | 25           | 25             | 45                   | 45                     | 25                   | 25                   | 25                      | 25                          | 25                           | 12                          | 45                | 25                    | 25            | 45              | 25            | 9                 | 45            | 25            | 25            | 25                       |
| 2 Increase return on investment        | 20  | 15       | 15       | 0        | 5                 | 20            | 5             | 0               | 5             | 15              | 25           | 45             | 45                   | 12                     | 12                   | 15                   | 15                      | 15                          | 15                           | 15                          | 15                | 45                    | 45            | 15              | 15            | 4                 | 20            | 20            | 20            | 20                       |
| 3 Minimize environmental impact        | 15  | 12       | 9        | 20       | 3                 | 20            | 4             | 3               | 4             | 3               | 9            | 36             | 36                   | 15                     | 25                   | 20                   | 3                       | 20                          | 20                           | 3                           | 27                | 36                    | 2             | 12              | 4             | 4                 | 15            | 5             | 4             |                          |
| 4 Improve your organization's image    | 20  | 20       | 9        | 15       | 3                 | 2             | 3             | 3               | 9             | 45              | 45           | 27             | 27                   | 27                     | 45                   | 15                   | 9                       | 18                          | 15                           | 10                          | 10                | 6                     | 6             | 20              | 9             | 2                 | 3             | 15            | 9             |                          |
| 5 Improve occupant comfort             | 15  | 20       | 25       | 5        | 9                 | 27            | 36            | 4               | 3             | 36              | 36           | 20             | 15                   | 20                     | 20                   | 12                   | 12                      | 3                           | 18                           | 18                          | 9                 | 9                     | 20            | 12              | 12            | 12                | 12            | 20            | 15            | 15                       |
| 6 Increase energy efficiency           | 20  | 15       | 25       | 4        | 25                | 15            | 15            | 15              | 15            | 25              | 25           | 45             | 45                   | 45                     | 45                   | 25                   | 25                      | 25                          | 25                           | 25                          | 36                | 36                    | 27            | 15              | 12            | 36                | 36            | 20            | 20            |                          |
| 7 Increase carbon neutrality           | 3   | 15       | 20       | 6        | 2                 | 1             | 6             | 2               | 1             | 3               | 15           | 15             | 10                   | 10                     | 5                    | 25                   | 15                      | 15                          | 3                            | 9                           | 0                 | 5                     | 0             | 15              | 3             | 2                 | 2             | 15            | 15            |                          |
| 8 Achieve lower total ownership costs  | 20  | 15       | 20       | 25       | 5                 | 12            | 15            | 4               | 4             | 45              | 45           | 45             | 45                   | 45                     | 25                   | 20                   | 20                      | 20                          | 25                           | 12                          | 15                | 20                    | 25            | 9               | 15            | 4                 | 45            | 45            | 25            | 25                       |
| 9 Meet regulatory requirements         | 12  | 9        | 6        | 4        | 5                 | 20            | 5             | 0               | 5             | 20              | 25           | 15             | 15                   | 45                     | 45                   | 12                   | 15                      | 9                           | 4                            | 15                          | 20                | 4                     | 3             | 9               | 5             | 4                 | 0             | 15            | 25            |                          |
| 10 Comply with policy or legislation   | 20  | 15       | 25       | 15       | 15                | 20            | 9             | 9               | 5             | 25              | 25           | 15             | 15                   | 45                     | 45                   | 45                   | 15                      | 15                          | 5                            | 12                          | 12                | 3                     | 3             | 15              | 5             | 20                | 20            | 25            | 15            |                          |
| 11 Improve aesthetic quality of site   | 18  | 27       | 10       | 20       | 20                | 6             | 0             | 0               | 18            | 18              | 27           | 36             | 27                   | 18                     | 18                   | 18                   | 10                      | 10                          | 27                           | 27                          | 6                 | 18                    | 9             | 3               | 27            | 0                 | 3             | 15            | 10            | 10                       |
| 12 Improve occupant productivity       | 12  | 25       | 15       | 15       | 0                 | 6             | 15            | 15              | 4             | 9               | 15           | 15             | 15                   | 20                     | 25                   | 20                   | 4                       | 12                          | 4                            | 3                           | 9                 | 9                     | 3             | 20              | 3             | 9                 | 9             | 4             | 4             |                          |
| 13 Reduce chance of opposition         | 36  | 10       | 10       | 9        | 9                 | 6             | 3             | 1               | 1             | 9               | 15           | 9              | 9                    | 9                      | 20                   | 20                   | 9                       | 9                           | 15                           | 12                          | 1                 | 9                     | 6             | 1               | 5             | 0                 | 1             | 0             | 20            | 20                       |
| 14 Increase property value             | 20  | 15       | 10       | 18       | 18                | 1             | 0             | 0               | 3             | 15              | 27           | 45             | 5                    | 18                     | 27                   | 6                    | 9                       | 15                          | 15                           | 9                           | 27                | 6                     | 3             | 15              | 1             | 15                | 15            | 3             | 6             |                          |
| 15 Reduce energy consumption           | 20  | 45       | 25       | 25       | 12                | 25            | 5             | 5               | 5             | 45              | 45           | 45             | 45                   | 25                     | 25                   | 25                   | 25                      | 25                          | 15                           | 15                          | 20                | 12                    | 9             | 45              | 12            | 9                 | 25            | 20            | 20            |                          |
| 16 Provide a secure energy supply      | 9   | 20       | 12       | 15       | 25                | 20            | 5             | 5               | 2             | 3               | 2            | 0              | 0                    | 2                      | 3                    | 9                    | 2                       | 4                           | 3                            | 0                           | 15                | 10                    | 0             | 20              | 0             | 2                 | 2             | 4             | 4             |                          |
| 17 Facilitate renewable energy         | 12  | 4        | 4        | 0        | 18                | 9             | 15            | 10              | 2             | 3               | 6            | 3              | 20                   | 20                     | 5                    | 5                    | 10                      | 15                          | 18                           | 18                          | 0                 | 9                     | 6             | 0               | 4             | 0                 | 0             | 20            | 20            | 9                        |
| 18 Lower project capital costs         | 0   | 0        | 0        | 0        | 25                | 20            | 36            | 36              | 4             | 4               | 0            | 45             | 0                    | 20                     | 0                    | 0                    | 0                       | 12                          | 0                            | 20                          | 4                 | 36                    | 36            | 4               | 0             | 0                 | 36            | 45            | 12            | 12                       |
| 19 Reduce costs of carbon offset       | 9   | 12       | 9        | 9        | 36                | 1             | 1             | 0               | 2             | 10              | 10           | 9              | 18                   | 10                     | 25                   | 6                    | 2                       | 9                           | 12                           | 3                           | 3                 | 1                     | 1             | 12              | 2             | 1                 | 6             | 3             | 1             |                          |
| 20 Achieve higher rental rates         | 20  | 15       | 10       | 0        | 9                 | 1             | 0             | 0               | 3             | 9               | 5            | 20             | 0                    | 0                      | 15                   | 10                   | 3                       | 3                           | 2                            | 6                           | 9                 | 27                    | 0             | 0               | 15            | 0                 | 6             | 6             | 15            | 20                       |
| 21 Achieve higher occupancy rates      | 12  | 12       | 15       | 3        | 9                 | 1             | 3             | 10              | 10            | 3               | 15           | 25             | 0                    | 0                      | 9                    | 9                    | 6                       | 6                           | 6                            | 1                           | 27                | 18                    | 1             | 6               | 0             | 2                 | 6             | 15            | 20            |                          |
| 22 Avoid costs due to opposition       | 36  | 6        | 15       | 2        | 4                 | 2             | 1             | 1               | 2             | 2               | 15           | 9              | 0                    | 0                      | 20                   | 15                   | 9                       | 9                           | 3                            | 2                           | 9                 | 3                     | 1             | 3               | 0             | 2                 | 2             | 15            | 20            |                          |
| 23 Gain the public's trust             | 20  | 20       | 20       | 12       | 4                 | 0             | 0             | 0               | 0             | 3               | 15           | 9              | 0                    | 0                      | 15                   | 25                   | 12                      | 6                           | 9                            | 3                           | 0                 | 6                     | 9             | 0               | 20            | 0                 | 0             | 9             | 12            | 4                        |
| 24 Decrease outages / interruptions    | 4   | 0        | 0        | 0        | 0                 | 20            | 4             | 4               | 3             | 3               | 12           | 9              | 25                   | 25                     | 3                    | 4                    | 5                       | 4                           | 0                            | 0                           | 6                 | 6                     | 0             | 0               | 0             | 0                 | 3             | 4             | 0             | 0                        |
| 25 Attract and retain employees        | 20  | 20       | 20       | 9        | 3                 | 1             | 9             | 25              | 25            | 9               | 12           | 12             | 36                   | 36                     | 15                   | 15                   | 20                      | 20                          | 6                            | 9                           | 15                | 10                    | 6             | 9               | 20            | 3                 | 6             | 6             | 1             | 1                        |
| 26 Improve occupant attendance         | 20  | 15       | 20       | 25       | 0                 | 2             | 2             | 10              | 15            | 3               | 12           | 12             | 9                    | 6                      | 25                   | 2                    | 2                       | 9                           | 15                           | 2                           | 2                 | 2                     | 2             | 2               | 9             | 2                 | 3             | 3             | 0             | 0                        |
| 27 Improve occupant health             | 12  | 12       | 20       | 25       | 15                | 12            | 3             | 9               | 6             | 2               | 12           | 12             | 9                    | 12                     | 6                    | 15                   | 0                       | 0                           | 9                            | 9                           | 3                 | 15                    | 15            | 3               | 12            | 4                 | 3             | 2             | 3             | 3                        |
| 28 Improve corporate reporting results | 3   | 45       | 25       | 20       | 15                | 20            | 4             | 1               | 4             | 2               | 12           | 12             | 12                   | 12                     | 6                    | 12                   | 25                      | 15                          | 9                            | 9                           | 2                 | 10                    | 20            | 3               | 45            | 3                 | 12            | 9             | 25            | 5                        |
| 29 Diversify investment portfolios     | 2   | 9        | 2        | 0        | 9                 | 1             | 0             | 0               | 1             | 2               | 9            | 9              | 0                    | 0                      | 6                    | 12                   | 2                       | 2                           | 12                           | 12                          | 6                 | 6                     | 0             | 0               | 9             | 0                 | 0             | 1             | 0             | 9                        |
| 30 Leverage business platforms         | 12  | 15       | 15       | 20       | 9                 | 4             | 0             | 0               | 2             | 4               | 9            | 0              | 0                    | 12                     | 12                   | 15                   | 15                      | 4                           | 4                            | 4                           | 4                 | 2                     | 0             | 0               | 15            | 0                 | 1             | 1             | 4             | 3                        |

**Table 36 – Building Envelope Technical Importance Rating Summary and Data Analysis Calculations, by Stakeholder Group**

| Potential Stakeholder Requirements: |                                     | Building Envelope Retrofits - Technical Importance |           |          |         |           |          |               |           |          |           |           |          |              |           |          |               |           |          |
|-------------------------------------|-------------------------------------|--|-----------|----------|---------|-----------|----------|---------------|-----------|----------|-----------|-----------|----------|--------------|-----------|----------|---------------|-----------|----------|
|                                     |                                     | Tenant   |           |          | Owner   |           |          | Facility Mgr. |           |          | Designers |           |          | Environmntl. |           |          | Weighted Avg. |           |          |
|                                     |                                     | Average  | Std. Dev. | Variance | Average | Std. Dev. | Variance | Average       | Std. Dev. | Variance | Average   | Std. Dev. | Variance | Average      | Std. Dev. | Variance | Average       | Std. Dev. | Variance |
| 1                                   | Reduce energy costs                 | 22   | 11        | 123      | 11.7    | 9.4       | 89       | 28.4          | 10        | 110      | 33.6      | 9.9       | 98       | 25           | 0         | 0        | 24.1          | 7.32      | 53.6     |
| 2                                   | Increase return on investment       | 12.5   | 7.5       | 56       | 8.33    | 9         | 81       | 23            | 13        | 176      | 25        | 13        | 164      | 20           | 0         | 0        | 17.8          | 6.35      | 40.3     |
| 3                                   | Minimize environmental impact       | 13.2   | 6         | 36       | 5.33    | 2.6       | 6.9      | 21.9          | 10        | 103      | 14.1      | 12        | 146      | 4.5          | 0.5       | 0.3      | 11.8          | 6.39      | 40.8     |
| 4                                   | Improve your organization's image   | 11.5   | 7.4       | 54       | 19      | 19        | 344      | 22.9          | 10        | 110      | 8.14      | 5.6       | 32       | 12           | 3         | 9        | 14.7          | 5.4       | 29.2     |
| 5                                   | Improve occupant comfort            | 15.7   | 6.9       | 47       | 23.7    | 15        | 214      | 15.3          | 5.7       | 33       | 15.1      | 4.6       | 21       | 15           | 0         | 0        | 16.9          | 3.37      | 11.3     |
| 6                                   | Increase energy efficiency          | 19   | 7.6       | 58       | 18.3    | 4.7       | 22       | 34.4          | 11        | 115      | 30.4      | 7.4       | 55       | 20           | 0         | 0        | 24.4          | 6.65      | 44.2     |
| 7                                   | Increase carbon neutrality          | 7.83   | 7.2       | 51       | 7       | 5.9       | 34       | 11.5          | 6.4       | 42       | 4.14      | 4.8       | 23       | 15           | 0         | 0        | 9.1           | 3.77      | 14.2     |
| 8                                   | Achieve lower total ownership costs | 16.2   | 6.5       | 42       | 20.8    | 18        | 308      | 26.5          | 11        | 128      | 24.9      | 14        | 183      | 25           | 0         | 0        | 22.7          | 3.76      | 14.1     |
| 9                                   | Meet regulatory requirements        | 9.33   | 5.5       | 30       | 9.17    | 9.8       | 95       | 20            | 15        | 221      | 7.86      | 6.7       | 45       | 20           | 5         | 25       | 13.3          | 5.52      | 30.4     |
| 10                                  | Comply with policy or legislation   | 18.3   | 3.7       | 14       | 13      | 8.6       | 75       | 22.5          | 14        | 194      | 12.1      | 6.5       | 43       | 20           | 5         | 25       | 17.2          | 4.01      | 16.1     |
| 11                                  | Improve aesthetic quality of site   | 16.8   | 6.9       | 48       | 16.5    | 13        | 173      | 19.4          | 6.7       | 44       | 11.6      | 8.2       | 68       | 10           | 0         | 0        | 14.9          | 3.5       | 12.3     |
| 12                                  | Improve occupant productivity       | 12.2   | 7.8       | 61       | 9.33    | 4.5       | 20       | 14.4          | 7.1       | 50       | 8.86      | 5.2       | 28       | 4            | 0         | 0        | 9.75          | 3.5       | 12.3     |
| 13                                  | Reduce chance of opposition         | 13.3   | 10        | 105      | 6.33    | 5.1       | 26       | 12.9          | 4.6       | 21       | 3.29      | 3.1       | 9.9      | 20           | 0         | 0        | 11.2          | 5.85      | 34.2     |
| 14                                  | Increase property value             | 13.7   | 6.5       | 42       | 15      | 17        | 273      | 12.5          | 7.2       | 53       | 12.9      | 7.3       | 53       | 4.5          | 1.5       | 2.3      | 11.7          | 3.7       | 13.7     |
| 15                                  | Reduce energy consumption           | 25.3   | 9.9       | 99       | 18.3    | 19        | 356      | 28.8          | 9.9       | 98       | 19.3      | 12        | 140      | 20           | 0         | 0        | 22.3          | 4.02      | 16.2     |
| 16                                  | Provide a secure energy supply      | 16.8   | 5.4       | 29       | 3.17    | 1.3       | 1.8      | 2.88          | 2.7       | 7.1      | 7         | 7.5       | 56       | 4            | 0         | 0        | 6.78          | 5.24      | 27.4     |
| 17                                  | Facilitate renewable energy         | 7.83   | 6         | 35       | 6.5     | 4.6       | 22       | 13.9          | 5.9       | 35       | 5.57      | 6.7       | 45       | 14.5         | 5.5       | 30       | 9.66          | 3.77      | 14.2     |
| 18                                  | Lower project capital costs         | 7.5  | 11        | 115      | 20.8    | 18        | 341      | 6.5           | 8.7       | 76       | 23        | 18        | 320      | 12           | 0         | 0        | 14            | 6.79      | 46       |
| 19                                  | Reduce costs of carbon offset       | 12.7   | 11        | 120      | 3.83    | 4.4       | 19       | 11.4          | 6.7       | 45       | 3.86      | 3.7       | 14       | 2            | 1         | 1        | 6.75          | 4.38      | 19.2     |
| 20                                  | Achieve higher rental rates         | 9.17   | 7.1       | 50       | 6.17    | 6.9       | 48       | 4.88          | 4.9       | 24       | 9         | 8.8       | 77       | 17.5         | 2.5       | 6.3      | 9.34          | 4.4       | 19.3     |
| 21                                  | Achieve higher occupancy rates      | 8.67   | 5.1       | 26       | 11      | 7.5       | 57       | 5.25          | 3.3       | 11       | 8.71      | 9.3       | 86       | 17.5         | 2.5       | 6.3      | 10.2          | 4.07      | 16.6     |
| 22                                  | Avoid costs due to opposition       | 10.8   | 12        | 146      | 5       | 5.3       | 28       | 9.5           | 7.7       | 59       | 3.14      | 2.5       | 6.1      | 17.5         | 2.5       | 6.3      | 9.2           | 5.02      | 25.2     |
| 23                                  | Gain the public's trust             | 12.7   | 8.1       | 66       | 5       | 5.4       | 29       | 8.75          | 8         | 63       | 6.29      | 6.8       | 46       | 8            | 4         | 16       | 8.14          | 2.61      | 6.84     |
| 24                                  | Decrease outages / interruptions    | 4  | 7.3       | 53       | 5.83    | 3.4       | 12       | 8.25          | 9.8       | 96       | 2.71      | 2.5       | 6.5      | 0            | 0         | 0        | 4.16          | 2.79      | 7.79     |
| 25                                  | Attract and retain employees        | 12.2   | 8.2       | 67       | 15.3    | 6.9       | 48       | 19.6          | 10        | 110      | 10.3      | 5         | 25       | 1            | 0         | 0        | 11.7          | 6.21      | 38.5     |
| 26                                  | Improve occupant attendance         | 13.7   | 9.4       | 89       | 9       | 4.8       | 23       | 11.6          | 8.7       | 75       | 3.29      | 2.4       | 5.6      | 0            | 0         | 0        | 7.52          | 5.12      | 26.3     |
| 27                                  | Improve occupant health             | 16   | 4.9       | 24       | 7.33    | 4         | 16       | 7.5           | 5         | 25       | 7.57      | 5.7       | 32       | 3            | 0         | 0        | 8.28          | 4.23      | 17.9     |
| 28                                  | Improve corporate reporting results | 21.3   | 13        | 159      | 5.83    | 4.5       | 20       | 12.5          | 5.4       | 29       | 14.4      | 14        | 187      | 15           | 10        | 100      | 13.8          | 4.97      | 24.7     |
| 29                                  | Diversify investment portfolios     | 3.83   | 3.7       | 14       | 3.5     | 3.9       | 16       | 5.75          | 5.1       | 26       | 3.14      | 3.5       | 12       | 4.5          | 4.5       | 20       | 4.15          | 0.92      | 0.84     |
| 30                                  | Leverage business platforms         | 12.5   | 5.1       | 26       | 2.83    | 3.1       | 9.5      | 7.75          | 6         | 36       | 3.29      | 4.9       | 24       | 3.5          | 0.5       | 0.3      | 5.97          | 3.71      | 13.8     |
| S                                   | Minimum                             | 3.8  |           |          | 2.8     |           |          | 2.9           |           |          | 2.7       |           |          | 0.0          |           |          | 4.1           |           |          |
| T                                   | 1st Quartile (lower 25%)            | 9.7  |           |          | 5.8     |           |          | 8.4           |           |          | 4.5       |           |          | 4.1          |           |          | 8.5           |           |          |
| A                                   | Median                              | 12.7   |           |          | 8.7     |           |          | 12.7          |           |          | 8.8       |           |          | 13.3         |           |          | 11.4          |           |          |
| T                                   | 3rd Quartile (upper 25%)            | 16.1   |           |          | 15.3    |           |          | 21.4          |           |          | 14.4      |           |          | 19.4         |           |          | 15.0          |           |          |
| S                                   | Maximum                             | 25.3   |           |          | 23.7    |           |          | 34.4          |           |          | 33.6      |           |          | 25.0         |           |          | 24.4          |           |          |

**Appendix G – HOQ Social Sustainability Considerations Relationship Data,  
Technical Importance Calculations, and Data Analysis Calculations**

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**Table 37 – Social Considerations, Relationship Rating Survey Data: HOQ Survey  
Individual Participant Responses**

| Potential Stakeholder Requirements: |                                     | Social Impact Vs. Stakeholder Requirements - Relationship Rating Data |          |          |          |                   |               |               |                 |               |                 |              |                |                      |                        |                      |                      |                         |                             |                              |                             |                   |                       |               |                 |               |                   |               |               |               |                          |
|-------------------------------------|-------------------------------------|---|----------|----------|----------|-------------------|---------------|---------------|-----------------|---------------|-----------------|--------------|----------------|----------------------|------------------------|----------------------|----------------------|-------------------------|-----------------------------|------------------------------|-----------------------------|-------------------|-----------------------|---------------|-----------------|---------------|-------------------|---------------|---------------|---------------|--------------------------|
|                                     |                                     | Tenant 4  | Tenant 3 | Tenant 2 | Tenant 1 | Tenant (Director) | Tenant (APWO) | Owner 1 (UEM) | Owner 2 (UEM-J) | Owner 3 (UEM) | Owner 4 (UEM-T) | Owner 5 (AM) | Owner 5 (AM-A) | Facility Mgr. 1 (CM) | Facility Mgr. 2 (CM-J) | Facility Mgr. 3 (EE) | Facility Mgr. 4 (ME) | Facility Mgr. 5 (Maint) | Facility Mgr. 6 (Maint - R) | Facility Mgr. 7 (Maint - K1) | Facility Mgr. 8 (Maint - K) | Designer (ME - B) | Designer 2 (ME - Byd) | Designer (ME) | Designer (ME-T) | Designer (PM) | Designer (PM - A) | Designer (CE) | Designer (TL) | Environmental | Environmental 2 (EV - S) |
| 1                                   | Reduce energy costs                 | 5   | 9        | 3        | 9        | 9                 | 0             | 3             | 3               | 5             | 5               | 5            | 3              | 3                    | 3                      | 9                    | 9                    | 5                       | 5                           | 3                            | 1                           | 3                 | 0                     | 0             | 3               | 9             | 1                 | 3             | 5             | 3             | 1                        |
| 2                                   | Increase return on investment       | 1   | 1        | 1        | 1        | 0                 | 3             | 3             | 3               | 3             | 0               | 0            | 9              | 9                    | 5                      | 5                    | 5                    | 5                       | 5                           | 0                            | 1                           | 0                 | 0                     | 0             | 0               | 1             | 0                 | 0             | 0             | 3             | 1                        |
| 3                                   | Minimize environmental impact       | 5   | 9        | 9        | 9        | 0                 | 5             | 5             | 5               | 5             | 5               | 5            | 9              | 9                    | 9                      | 9                    | 9                    | 5                       | 9                           | 9                            | 5                           | 3                 | 3                     | 5             | 9               | 3             | 5                 | 9             | 3             | 5             | 5                        |
| 4                                   | Improve your organization's image   | 5   | 5        | 9        | 5        | 5                 | 0             | 3             | 5               | 5             | 3               | 5            | 5              | 5                    | 9                      | 9                    | 9                    | 3                       | 3                           | 9                            | 9                           | 1                 | 3                     | 3             | 1               | 5             | 0                 | 3             | 3             | 5             | 5                        |
| 5                                   | Improve occupant comfort            | 5   | 5        | 5        | 5        | 0                 | 3             | 3             | 3               | 3             | 3               | 5            | 5              | 5                    | 9                      | 9                    | 9                    | 3                       | 3                           | 5                            | 5                           | 0                 | 1                     | 1             | 0               | 5             | 3                 | 5             | 5             | 3             | 1                        |
| 6                                   | Increase energy efficiency          | 1   | 5        | 5        | 5        | 0                 | 3             | 3             | 3               | 3             | 3               | 3            | 5              | 5                    | 9                      | 9                    | 9                    | 5                       | 5                           | 3                            | 3                           | 3                 | 0                     | 0             | 3               | 5             | 3                 | 3             | 5             | 5             | 1                        |
| 7                                   | Increase carbon neutrality          | 3   | 5        | 9        | 5        | 5                 | 0             | 1             | 3               | 3             | 1               | 3            | 3              | 9                    | 9                      | 9                    | 9                    | 5                       | 9                           | 9                            | 3                           | 1                 | 1                     | 3             | 5               | 3             | 3                 | 3             | 5             | 5             | 1                        |
| 8                                   | Achieve lower total ownership costs | 1   | 1        | 3        | 1        | 1                 | 0             | 1             | 3               | 3             | 1               | 1            | 5              | 5                    | 5                      | 5                    | 3                    | 3                       | 1                           | 1                            | 0                           | 0                 | 0                     | 0             | 1               | 0             | 0                 | 1             | 0             | 1             | 1                        |
| 9                                   | Meet regulatory requirements        | 3   | 5        | 3        | 5        | 5                 | 0             | 3             | 3               | 3             | 3               | 3            | 3              | 9                    | 9                      | 1                    | 1                    | 9                       | 9                           | 3                            | 3                           | 3                 | 3                     | 3             | 5               | 3             | 5                 | 3             | 5             | 1             | 1                        |
| 10                                  | Comply with policy or legislation   | 3   | 3        | 5        | 3        | 3                 | 5             | 3             | 5               | 3             | 3               | 1            | 1              | 3                    | 3                      | 9                    | 9                    | 5                       | 1                           | 9                            | 9                           | 1                 | 3                     | 3             | 1               | 3             | 5                 | 5             | 5             | 3             | 0                        |
| 11                                  | Improve aesthetic quality of site   | 5   | 5        | 5        | 5        | 0                 | 5             | 1             | 1               | 5             | 5               | 5            | 9              | 9                    | 9                      | 9                    | 9                    | 3                       | 1                           | 9                            | 9                           | 5                 | 5                     | 3             | 3               | 5             | 3                 | 3             | 3             | 3             | 1                        |
| 12                                  | Improve occupant productivity       | 5   | 5        | 5        | 5        | 0                 | 3             | 3             | 3               | 3             | 3               | 5            | 5              | 5                    | 9                      | 9                    | 9                    | 5                       | 3                           | 9                            | 9                           | 1                 | 1                     | 0             | 0               | 5             | 3                 | 0             | 3             | 1             | 0                        |
| 13                                  | Reduce chance of opposition         | 1   | 5        | 3        | 5        | 5                 | 1             | 3             | 3               | 3             | 5               | 5            | 5              | 5                    | 9                      | 9                    | 5                    | 9                       | 9                           | 9                            | 9                           | 3                 | 3                     | 5             | 1               | 3             | 3                 | 5             | 5             | 5             | 5                        |
| 14                                  | Increase property value             | 1   | 0        | 3        | 0        | 0                 | 1             | 1             | 1               | 1             | 1               | 1            | 5              | 5                    | 1                      | 3                    | 0                    | 3                       | 0                           | 3                            | 0                           | 0                 | 0                     | 0             | 0               | 0             | 0                 | 0             | 0             | 0             | 0                        |
| 15                                  | Reduce energy consumption           | 5   | 9        | 9        | 9        | 0                 | 3             | 3             | 5               | 5             | 1               | 1            | 5              | 5                    | 5                      | 5                    | 5                    | 5                       | 5                           | 5                            | 5                           | 1                 | 1                     | 3             | 3               | 9             | 1                 | 5             | 5             | 9             | 3                        |
| 16                                  | Provide a secure energy supply      | 5   | 5        | 9        | 5        | 5                 | 0             | 3             | 3               | 1             | 1               | 9            | 9              | 0                    | 0                      | 3                    | 3                    | 5                       | 0                           | 9                            | 9                           | 3                 | 3                     | 0             | 0               | 5             | 3                 | 0             | 0             | 5             | 1                        |
| 17                                  | Facilitate renewable energy         | 5   | 9        | 9        | 9        | 1                 | 5             | 5             | 3               | 5             | 5               | 5            | 5              | 5                    | 9                      | 9                    | 5                    | 3                       | 5                           | 3                            | 3                           | 3                 | 3                     | 3             | 9               | 3             | 3                 | 3             | 5             | 3             | 3                        |
| 18                                  | Lower project capital costs         | 0   | 0        | 0        | 0        | 1                 | 5             | 0             | 0               | 5             | 3               | 3            | 3              | 3                    | 9                      | 9                    | 0                    | 0                       | 0                           | 0                            | 0                           | 1                 | 1                     | 0             | 0               | 1             | 0                 | 0             | 1             | 0             | 1                        |
| 19                                  | Reduce costs of carbon offset       | 3   | 5        | 5        | 5        | 0                 | 3             | 3             | 3               | 3             | 5               | 5            | 3              | 3                    | 9                      | 9                    | 3                    | 9                       | 9                           | 5                            | 5                           | 3                 | 3                     | 5             | 1               | 3             | 5                 | 1             | 3             | 3             | 1                        |
| 20                                  | Achieve higher rental rates         | 1   | 0        | 3        | 0        | 0                 | 5             | 1             | 0               | 0             | 1               | 5            | 5              | 3                    | 3                      | 3                    | 3                    | 0                       | 0                           | 3                            | 3                           | 0                 | 0                     | 3             | 0               | 0             | 1                 | 0             | 0             | 0             | 0                        |
| 21                                  | Achieve higher occupancy rates      | 3   | 0        | 3        | 0        | 0                 | 3             | 1             | 0               | 0             | 1               | 5            | 5              | 1                    | 1                      | 9                    | 3                    | 3                       | 0                           | 0                            | 3                           | 0                 | 0                     | 3             | 0               | 1             | 0                 | 0             | 0             | 0             | 0                        |
| 22                                  | Avoid costs due to opposition       | 1   | 5        | 5        | 5        | 1                 | 3             | 3             | 3               | 3             | 5               | 5            | 3              | 3                    | 3                      | 3                    | 5                    | 5                       | 9                           | 9                            | 3                           | 5                 | 5                     | 3             | 5               | 1             | 3                 | 1             | 5             | 5             | 5                        |
| 23                                  | Gain the public's trust             | 5   | 5        | 5        | 5        | 1                 | 5             | 5             | 3               | 3             | 5               | 5            | 5              | 5                    | 3                      | 3                    | 3                    | 3                       | 3                           | 9                            | 9                           | 3                 | 5                     | 5             | 3               | 3             | 3                 | 3             | 5             | 3             | 3                        |
| 24                                  | Decrease outages / interruptions    | 5   | 5        | 5        | 5        | 1                 | 0             | 0             | 3               | 3             | 1               | 1            | 5              | 5                    | 5                      | 5                    | 5                    | 0                       | 0                           | 5                            | 5                           | 1                 | 0                     | 0             | 1               | 5             | 0                 | 0             | 0             | 0             | 0                        |
| 25                                  | Attract and retain employees        | 5   | 5        | 5        | 5        | 1                 | 1             | 3             | 3               | 1             | 3               | 3            | 3              | 3                    | 5                      | 5                    | 3                    | 5                       | 0                           | 3                            | 3                           | 0                 | 3                     | 3             | 0               | 5             | 3                 | 1             | 1             | 3             | 3                        |
| 26                                  | Improve occupant attendance         | 5   | 5        | 5        | 5        | 1                 | 1             | 5             | 5               | 1             | 3               | 3            | 3              | 3                    | 5                      | 5                    | 0                    | 0                       | 5                           | 5                            | 0                           | 3                 | 3                     | 0             | 5               | 3             | 0                 | 1             | 0             | 0             |                          |
| 27                                  | Improve occupant health             | 5   | 9        | 5        | 9        | 1                 | 3             | 3             | 3               | 3             | 5               | 5            | 5              | 5                    | 5                      | 5                    | 3                    | 3                       | 5                           | 9                            | 9                           | 0                 | 0                     | 0             | 0               | 9             | 3                 | 0             | 3             | 5             | 0                        |
| 28                                  | Improve corporate reporting results | 5   | 9        | 5        | 9        | 9                 | 3             | 1             | 5               | 5             | 1               | 1            | 5              | 5                    | 3                      | 3                    | 5                    | 3                       | 5                           | 9                            | 9                           | 0                 | 0                     | 0             | 0               | 9             | 1                 | 5             | 5             | 5             | 5                        |
| 29                                  | Diversify investment portfolios     | 3   | 0        | 1        | 0        | 0                 | 0             | 1             | 1               | 1             | 1               | 3            | 3              | 0                    | 0                      | 3                    | 3                    | 3                       | 3                           | 1                            | 1                           | 0                 | 0                     | 0             | 0               | 1             | 1                 | 1             | 1             | 3             | 3                        |
| 30                                  | Leverage business platforms         | 1   | 5        | 1        | 5        | 5                 | 0             | 0             | 1               | 1             | 3               | 3            | 0              | 0                    | 3                      | 3                    | 5                    | 5                       | 1                           | 1                            | 0                           | 0                 | 0                     | 0             | 5               | 1             | 3                 | 3             | 9             | 3             | 3                        |

**Table 38 – Social Considerations Technical Importance Calculations: Results for each Individual Participant**

| Potential Stakeholder Requirements: |                                     | Social Impact - Summary of Technical Importance |          |          |          |                   |               |               |                 |               |                 |              |                |                      |                        |                      |                      |                         |                             |                              |                             |                   |                       |               |                   |               |                   |               |               |               |                          |
|-------------------------------------|-------------------------------------|---|----------|----------|----------|-------------------|---------------|---------------|-----------------|---------------|-----------------|--------------|----------------|----------------------|------------------------|----------------------|----------------------|-------------------------|-----------------------------|------------------------------|-----------------------------|-------------------|-----------------------|---------------|-------------------|---------------|-------------------|---------------|---------------|---------------|--------------------------|
|                                     |                                     | Tenant 4  | Tenant 3 | Tenant 2 | Tenant 1 | Tenant (Director) | Tenant (APWO) | Owner 1 (UEM) | Owner 2 (UEM-J) | Owner 3 (UEM) | Owner 4 (UEM-T) | Owner 5 (AM) | Owner 5 (AM-A) | Facility Mgr. 1 (CM) | Facility Mgr. 2 (CM-J) | Facility Mgr. 3 (EE) | Facility Mgr. 4 (ME) | Facility Mgr. 5 (Maint) | Facility Mgr. 6 (Maint - R) | Facility Mgr. 7 (Maint - K1) | Facility Mgr. 8 (Maint - K) | Designer (ME - B) | Designer 2 (ME - Byd) | Designer (ME) | Designer (ME - T) | Designer (PM) | Designer (PM - A) | Designer (CE) | Designer (TL) | Environmental | Environmental 2 (EV - S) |
| 1                                   | Reduce energy costs                 | 20  | 45       | 15       | 45       | 36                | 0             | 15            | 15              | 25            | 25              | 15           | 15             | 15                   | 45                     | 45                   | 25                   | 25                      | 15                          | 4                            | 15                          | 0                 | 0                     | 15            | 45                | 3             | 15                | 25            | 15            | 5             |                          |
| 2                                   | Increase return on investment       | 4   | 5        | 5        | 5        | 5                 | 0             | 15            | 15              | 15            | 15              | 0            | 0              | 45                   | 45                     | 20                   | 20                   | 25                      | 25                          | 0                            | 5                           | 0                 | 0                     | 0             | 5                 | 0             | 0                 | 0             | 12            | 4             |                          |
| 3                                   | Minimize environmental impact       | 15  | 36       | 27       | 36       | 27                | 0             | 20            | 15              | 20            | 15              | 15           | 15             | 36                   | 36                     | 27                   | 45                   | 20                      | 15                          | 36                           | 36                          | 15                | 9                     | 12            | 10                | 36            | 12                | 20            | 15            | 20            |                          |
| 4                                   | Improve your organization's image   | 20  | 20       | 27       | 15       | 15                | 0             | 9             | 15              | 15            | 9               | 25           | 25             | 15                   | 15                     | 27                   | 45                   | 9                       | 9                           | 18                           | 27                          | 2                 | 6                     | 6             | 2                 | 20            | 0                 | 6             | 9             | 15            |                          |
| 5                                   | Improve occupant comfort            | 15  | 20       | 20       | 25       | 25                | 0             | 9             | 12              | 12            | 9               | 20           | 20             | 15                   | 36                     | 36                   | 12                   | 12                      | 20                          | 15                           | 0                           | 2                 | 3                     | 0             | 20                | 12            | 20                | 20            | 9             | 3             |                          |
| 6                                   | Increase energy efficiency          | 4   | 25       | 25       | 20       | 0                 | 15            | 15            | 15              | 15            | 15              | 15           | 15             | 25                   | 45                     | 45                   | 25                   | 15                      | 12                          | 12                           | 0                           | 0                 | 9                     | 25            | 12                | 12            | 20                | 20            | 4             |               |                          |
| 7                                   | Increase carbon neutrality          | 9   | 15       | 36       | 10       | 10                | 0             | 2             | 6               | 3             | 1               | 9            | 9              | 18                   | 18                     | 9                    | 45                   | 15                      | 15                          | 9                            | 27                          | 0                 | 1                     | 1             | 0                 | 15            | 9                 | 6             | 15            | 15            |                          |
| 8                                   | Achieve lower total ownership costs | 4   | 5        | 12       | 5        | 0                 | 5             | 4             | 12              | 5             | 4               | 12           | 5              | 4                    | 0                      | 0                    | 4                    | 0                       | 0                           | 0                            | 0                           | 0                 | 0                     | 0             | 0                 | 0             | 0                 | 5             | 5             | 5             |                          |
| 9                                   | Meet regulatory requirements        | 12  | 15       | 6        | 20       | 25                | 0             | 15            | 9               | 9             | 15              | 12           | 15             | 15                   | 45                     | 45                   | 4                    | 5                       | 27                          | 36                           | 9                           | 12                | 12                    | 9             | 15                | 15            | 20                | 20            | 5             | 5             |                          |
| 10                                  | Comply with policy or legislation   | 12  | 15       | 25       | 15       | 15                | 12            | 15            | 15              | 15            | 15              | 5            | 5              | 15                   | 45                     | 45                   | 25                   | 5                       | 45                          | 45                           | 4                           | 12                | 9                     | 3             | 15                | 15            | 20                | 20            | 15            | 0             |                          |
| 11                                  | Improve aesthetic quality of site   | 10  | 15       | 10       | 20       | 20                | 0             | 10            | 2               | 10            | 15              | 20           | 27             | 18                   | 18                     | 18                   | 6                    | 2                       | 27                          | 27                           | 10                          | 10                | 3                     | 3             | 15                | 0             | 3                 | 9             | 6             | 2             |                          |
| 12                                  | Improve occupant productivity       | 20  | 25       | 15       | 25       | 25                | 0             | 9             | 12              | 12            | 15              | 15           | 15             | 36                   | 45                     | 20                   | 12                   | 36                      | 36                          | 3                            | 3                           | 0                 | 0                     | 0             | 20                | 9             | 0                 | 9             | 4             | 0             |                          |
| 13                                  | Reduce chance of opposition         | 4   | 10       | 6        | 15       | 15                | 2             | 3             | 3               | 3             | 9               | 15           | 15             | 15                   | 36                     | 36                   | 15                   | 15                      | 27                          | 36                           | 9                           | 27                | 6                     | 3             | 5                 | 0             | 3                 | 6             | 20            | 20            |                          |
| 14                                  | Increase property value             | 4   | 0        | 6        | 0        | 0                 | 0             | 0             | 0               | 0             | 3               | 3            | 5              | 5                    | 2                      | 3                    | 6                    | 0                       | 9                           | 0                            | 3                           | 9                 | 0                     | 0             | 0                 | 0             | 0                 | 0             | 0             | 0             | 0                        |
| 15                                  | Reduce energy consumption           | 20  | 45       | 45       | 45       | 36                | 0             | 15            | 15              | 25            | 25              | 5            | 5              | 25                   | 25                     | 25                   | 25                   | 25                      | 25                          | 25                           | 3                           | 4                 | 12                    | 9             | 45                | 4             | 15                | 25            | 36            | 12            |                          |
| 16                                  | Provide a secure energy supply      | 15  | 20       | 36       | 15       | 25                | 0             | 15            | 15              | 2             | 2               | 27           | 18             | 0                    | 6                      | 9                    | 15                   | 0                       | 36                          | 27                           | 9                           | 9                 | 0                     | 0             | 20                | 0             | 0                 | 0             | 20            | 4             |                          |
| 17                                  | Facilitate renewable energy         | 20  | 36       | 36       | 18       | 18                | 3             | 15            | 10              | 6             | 9               | 10           | 15             | 20                   | 45                     | 45                   | 10                   | 9                       | 10                          | 10                           | 9                           | 9                 | 6                     | 6             | 36                | 6             | 12                | 12            | 20            | 9             |                          |
| 18                                  | Lower project capital costs         | 0   | 0        | 0        | 0        | 0                 | 4             | 20            | 0               | 0             | 20              | 12           | 15             | 0                    | 12                     | 27                   | 0                    | 0                       | 0                           | 0                            | 4                           | 4                 | 0                     | 0             | 0                 | 0             | 0                 | 0             | 4             | 4             |                          |
| 19                                  | Reduce costs of carbon offset       | 9   | 20       | 15       | 15       | 20                | 0             | 3             | 3               | 6             | 6               | 10           | 10             | 3                    | 6                      | 18                   | 45                   | 6                       | 6                           | 27                           | 36                          | 5                 | 5                     | 3             | 20                | 2             | 3                 | 6             | 1             | 1             |                          |
| 20                                  | Achieve higher rental rates         | 4   | 0        | 6        | 0        | 0                 | 5             | 0             | 0               | 0             | 3               | 5            | 20             | 3                    | 0                      | 9                    | 6                    | 3                       | 3                           | 0                            | 0                           | 3                 | 9                     | 0             | 0                 | 1             | 0                 | 0             | 0             | 0             |                          |
| 21                                  | Achieve higher occupancy rates      | 12  | 0        | 9        | 0        | 0                 | 3             | 3             | 0               | 0             | 3               | 15           | 25             | 1                    | 0                      | 27                   | 27                   | 6                       | 6                           | 0                            | 0                           | 0                 | 6                     | 0             | 0                 | 1             | 0                 | 0             | 0             | 0             |                          |
| 22                                  | Avoid costs due to opposition       | 4   | 10       | 15       | 10       | 20                | 2             | 3             | 3               | 6             | 6               | 15           | 15             | 9                    | 12                     | 12                   | 15                   | 15                      | 27                          | 27                           | 6                           | 15                | 5                     | 3             | 5                 | 0             | 6                 | 2             | 15            | 20            |                          |
| 23                                  | Gain the public's trust             | 20  | 20       | 20       | 20       | 20                | 0             | 15            | 15              | 9             | 9               | 15           | 15             | 25                   | 25                     | 9                    | 15                   | 12                      | 6                           | 27                           | 27                          | 6                 | 10                    | 15            | 9                 | 20            | 0                 | 9             | 9             | 20            | 12                       |
| 24                                  | Decrease outages / interruptions    | 20  | 20       | 25       | 25       | 25                | 4             | 0             | 0               | 9             | 4               | 3            | 25             | 25                   | 15                     | 20                   | 0                    | 0                       | 15                          | 15                           | 2                           | 0                 | 0                     | 3             | 20                | 0             | 0                 | 0             | 0             | 0             |                          |
| 25                                  | Attract and retain employees        | 20  | 20       | 15       | 15       | 15                | 1             | 3             | 15              | 15            | 3               | 12           | 12             | 12                   | 12                     | 25                   | 25                   | 12                      | 10                          | 15                           | 0                           | 6                 | 6                     | 0             | 20                | 9             | 2                 | 3             | 3             |               |                          |
| 26                                  | Improve occupant attendance         | 20  | 25       | 20       | 25       | 25                | 2             | 2             | 10              | 15            | 3               | 12           | 12             | 9                    | 6                      | 25                   | 25                   | 0                       | 0                           | 15                           | 0                           | 6                 | 6                     | 0             | 15                | 6             | 0                 | 3             | 0             | 0             |                          |
| 27                                  | Improve occupant health             | 20  | 36       | 20       | 45       | 45                | 4             | 9             | 9               | 6             | 6               | 20           | 20             | 15                   | 20                     | 10                   | 25                   | 6                       | 9                           | 27                           | 27                          | 0                 | 0                     | 0             | 36                | 12            | 0                 | 6             | 15            | 0             |                          |
| 28                                  | Improve corporate reporting results | 15  | 45       | 25       | 36       | 27                | 12            | 4             | 5               | 20            | 2               | 4            | 20             | 20                   | 6                      | 12                   | 25                   | 15                      | 27                          | 27                           | 0                           | 0                 | 0                     | 0             | 45                | 3             | 20                | 15            | 25            | 25            |                          |
| 29                                  | Diversify investment portfolios     | 6   | 0        | 2        | 0        | 0                 | 0             | 2             | 1               | 1             | 2               | 9            | 9              | 0                    | 0                      | 6                    | 12                   | 6                       | 6                           | 4                            | 4                           | 0                 | 0                     | 0             | 0                 | 0             | 0                 | 1             | 1             | 3             | 9                        |
| 30                                  | Leverage business platforms         | 4   | 25       | 5        | 20       | 5                 | 0             | 0             | 0               | 2             | 12              | 9            | 0              | 0                    | 12                     | 12                   | 15                   | 15                      | 4                           | 4                            | 0                           | 0                 | 0                     | 0             | 25                | 1             | 3                 | 3             | 36            | 9             |                          |

**Table 39 – Social Considerations Technical Importance Rating Summary and Data Analysis Calculations, by Stakeholder Group**

| Potential Stakeholder Requirements: |                                     | Social Impact - Technical Importance |           |          |         |           |          |               |           |          |           |           |          |              |           |          |               |           |          |  |  |  |
|-------------------------------------|-------------------------------------|--------------------------------------|-----------|----------|---------|-----------|----------|---------------|-----------|----------|-----------|-----------|----------|--------------|-----------|----------|---------------|-----------|----------|--|--|--|
|                                     |                                     | Tenant                               |           |          | Owner   |           |          | Facility Mgr. |           |          | Designers |           |          | Environmntl. |           |          | Weighted Avg. |           |          |  |  |  |
|                                     |                                     | Average                              | Std. Dev. | Variance | Average | Std. Dev. | Variance | Average       | Std. Dev. | Variance | Average   | Std. Dev. | Variance | Average      | Std. Dev. | Variance | Average       | Std. Dev. | Variance |  |  |  |
| 1                                   | Reduce energy costs                 | 26.8                                 | 17        | 275      | 20      | 5         | 25       | 23.6          | 14        | 191      | 16.4      | 14        | 205      | 10           | 5         | 25       | 19.4          | 5.84      | 34.1     |  |  |  |
| 2                                   | Increase return on investment       | 4                                    | 1.8       | 3.3      | 10      | 7.1       | 50       | 23.1          | 15        | 231      | 0.71      | 1.7       | 3.1      | 8            | 4         | 16       | 9.17          | 7.68      | 59       |  |  |  |
| 3                                   | Minimize environmental impact       | 23.5                                 | 13        | 160      | 16.7    | 2.4       | 5.6      | 31.4          | 9.3       | 86       | 16.7      | 8.6       | 74       | 22.5         | 2.5       | 6.3      | 22.2          | 5.42      | 29.3     |  |  |  |
| 4                                   | Improve your organization's image   | 16.2                                 | 8.3       | 68       | 16.3    | 6.6       | 44       | 20.6          | 11        | 127      | 7.29      | 5.7       | 32       | 15           | 0         | 0        | 15.1          | 4.34      | 18.9     |  |  |  |
| 5                                   | Improve occupant comfort            | 17.5                                 | 8.5       | 73       | 13.7    | 4.6       | 22       | 20.8          | 9.3       | 86       | 9.29      | 9.3       | 87       | 6            | 3         | 9        | 13.4          | 5.34      | 28.5     |  |  |  |
| 6                                   | Increase energy efficiency          | 16.5                                 | 10        | 110      | 15      | 0         | 0        | 27.1          | 11        | 129      | 11.1      | 8.7       | 75       | 12           | 8         | 64       | 16.4          | 5.73      | 32.8     |  |  |  |
| 7                                   | Increase carbon neutrality          | 13.3                                 | 11        | 123      | 5       | 3.2       | 10       | 19.5          | 11        | 122      | 4.14      | 5.1       | 26       | 15           | 0         | 0        | 11.4          | 5.93      | 35.2     |  |  |  |
| 8                                   | Achieve lower total ownership costs | 5.17                                 | 3.5       | 12       | 7.17    | 3.4       | 12       | 16            | 8.3       | 70       | 1.43      | 2.3       | 5.1      | 5            | 0         | 0        | 6.95          | 4.89      | 23.9     |  |  |  |
| 9                                   | Meet regulatory requirements        | 13                                   | 8.3       | 69       | 12.5    | 2.7       | 7.3      | 24            | 16        | 245      | 13.9      | 4.3       | 19       | 5            | 0         | 0        | 13.7          | 6.06      | 36.7     |  |  |  |
| 10                                  | Comply with policy or legislation   | 15.7                                 | 4.4       | 19       | 11.7    | 4.7       | 22       | 30            | 16        | 250      | 11.9      | 6.4       | 42       | 7.5          | 7.5       | 56       | 15.3          | 7.77      | 60.4     |  |  |  |
| 11                                  | Improve aesthetic quality of site   | 12.5                                 | 6.9       | 48       | 9.83    | 6.5       | 42       | 17.9          | 9         | 80       | 7.57      | 4.3       | 19       | 4            | 2         | 4        | 10.4          | 4.68      | 21.9     |  |  |  |
| 12                                  | Improve occupant productivity       | 18.3                                 | 9         | 81       | 12      | 2.4       | 6        | 26.9          | 12        | 141      | 5         | 6.8       | 46       | 2            | 2         | 4        | 12.8          | 9.02      | 81.4     |  |  |  |
| 13                                  | Reduce chance of opposition         | 8.67                                 | 5.1       | 26       | 8       | 5.4       | 29       | 24.4          | 9.8       | 95       | 8.43      | 7.8       | 61       | 20           | 0         | 0        | 13.9          | 6.91      | 47.8     |  |  |  |
| 14                                  | Increase property value             | 1.67                                 | 2.4       | 5.9      | 2.33    | 1.8       | 3.2      | 3.75          | 2.9       | 8.4      | 1.71      | 3.1       | 9.9      | 0            | 0         | 0        | 1.89          | 1.21      | 1.46     |  |  |  |
| 15                                  | Reduce energy consumption           | 31.8                                 | 17        | 282      | 15      | 8.2       | 67       | 25            | 0         | 0        | 16.1      | 14        | 186      | 24           | 12        | 144      | 22.4          | 6.2       | 38.4     |  |  |  |
| 16                                  | Provide a secure energy supply      | 18.5                                 | 11        | 120      | 13.2    | 8.9       | 78       | 11.6          | 13        | 161      | 5.43      | 7.1       | 51       | 12           | 8         | 64       | 12.1          | 4.17      | 17.4     |  |  |  |
| 17                                  | Facilitate renewable energy         | 21.8                                 | 11        | 131      | 10.8    | 3.2       | 10       | 21.1          | 14        | 208      | 12.9      | 9.7       | 94       | 14.5         | 5.5       | 30       | 16.2          | 4.45      | 19.8     |  |  |  |
| 18                                  | Lower project capital costs         | 0.67                                 | 1.5       | 2.2      | 11.2    | 8.4       | 70       | 8.25          | 11        | 132      | 1.14      | 1.8       | 3.3      | 4            | 0         | 0        | 5.05          | 4.08      | 16.6     |  |  |  |
| 19                                  | Reduce costs of carbon offset       | 13.2                                 | 7         | 48       | 6.33    | 2.9       | 8.2      | 18.4          | 15        | 224      | 6.43      | 5.7       | 32       | 1            | 0         | 0        | 9.06          | 6.05      | 36.6     |  |  |  |
| 20                                  | Achieve higher rental rates         | 2.5                                  | 2.6       | 6.6      | 4.67    | 7.1       | 51       | 3             | 3         | 9        | 1.71      | 3.1       | 9.9      | 0            | 0         | 0        | 2.38          | 1.53      | 2.35     |  |  |  |
| 21                                  | Achieve higher occupancy rates      | 4                                    | 4.8       | 23       | 7.67    | 9.3       | 86       | 8.38          | 11        | 121      | 2.14      | 3.5       | 12       | 0            | 0         | 0        | 4.44          | 3.2       | 10.2     |  |  |  |
| 22                                  | Avoid costs due to opposition       | 10.2                                 | 6.1       | 37       | 8       | 5.1       | 26       | 15.8          | 6.8       | 47       | 6         | 3.9       | 15       | 17.5         | 2.5       | 6.3      | 11.5          | 4.43      | 19.7     |  |  |  |
| 23                                  | Gain the public's trust             | 16.7                                 | 7.5       | 56       | 13      | 2.8       | 8        | 18.3          | 8.1       | 66       | 11.1      | 4.4       | 19       | 16           | 4         | 16       | 15            | 2.58      | 6.64     |  |  |  |
| 24                                  | Decrease outages / interruptions    | 19.8                                 | 7.4       | 55       | 4.17    | 3.7       | 14       | 14.4          | 9.2       | 84       | 3.57      | 6.8       | 46       | 0            | 0         | 0        | 8.39          | 7.46      | 55.6     |  |  |  |
| 25                                  | Attract and retain employees        | 15.2                                 | 6.7       | 45       | 10      | 5.1       | 26       | 15.4          | 5.7       | 32       | 5.14      | 6.5       | 42       | 3            | 0         | 0        | 9.74          | 5.06      | 25.6     |  |  |  |
| 26                                  | Improve occupant attendance         | 19.5                                 | 8.1       | 66       | 9       | 4.8       | 23       | 11.9          | 9.3       | 86       | 4.29      | 5         | 25       | 0            | 0         | 0        | 8.93          | 6.66      | 44.3     |  |  |  |
| 27                                  | Improve occupant health             | 28.3                                 | 15        | 224      | 11.7    | 6         | 36       | 17.4          | 8         | 64       | 6         | 12        | 154      | 7.5          | 7.5       | 56       | 14.2          | 8.1       | 65.7     |  |  |  |
| 28                                  | Improve corporate reporting results | 26.7                                 | 11        | 130      | 6.5     | 6.1       | 37       | 19            | 7.1       | 50       | 11.4      | 16        | 248      | 25           | 0         | 0        | 17.7          | 7.75      | 60       |  |  |  |
| 29                                  | Diversify investment portfolios     | 1.33                                 | 2.2       | 4.9      | 4       | 3.6       | 13       | 4.75          | 3.6       | 13       | 0.29      | 0.5       | 0.2      | 6            | 3         | 9        | 3.27          | 2.14      | 4.57     |  |  |  |
| 30                                  | Leverage business platforms         | 9.83                                 | 9.2       | 85       | 4.17    | 4.6       | 21       | 7.75          | 6         | 36       | 4.43      | 8.5       | 72       | 22.5         | 14        | 182      | 9.74          | 6.72      | 45.2     |  |  |  |
| S                                   | Minimum                             | 0.7                                  |           |          | 2.3     |           |          | 3.0           |           |          | 0.3       |           |          | 0.0          |           |          | 1.9           |           |          |  |  |  |
| T                                   | 1st Quartile (lower 25%)            | 9.0                                  |           |          | 6.7     |           |          | 12.5          |           |          | 3.7       |           |          | 3.3          |           |          | 9.0           |           |          |  |  |  |
| A                                   | Median                              | 15.4                                 |           |          | 10.0    |           |          | 18.3          |           |          | 6.0       |           |          | 7.5          |           |          | 11.8          |           |          |  |  |  |
| T                                   | 3rd Quartile (upper 25%)            | 19.3                                 |           |          | 12.9    |           |          | 23.5          |           |          | 11.1      |           |          | 15.0         |           |          | 15.1          |           |          |  |  |  |
| S                                   | Maximum                             | 31.8                                 |           |          | 20.0    |           |          | 31.4          |           |          | 16.7      |           |          | 25.0         |           |          | 22.4          |           |          |  |  |  |

**Appendix H – HOQ Environmental Sustainability Considerations  
Relationship Data, Technical Importance Calculations, and Data Analysis  
Calculations**

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**Table 41 – Environmental Considerations Technical Importance Calculations: Results for each Individual Participant**

| Potential Stakeholder Requirements: |                                     | Environmental Impact - Summary of Technical Importance |          |          |          |                   |               |               |                 |               |                 |              |                |                      |                        |                      |                      |                         |                             |                              |                             |                   |                       |               |                   |               |                   |               |               |               |                          |
|-------------------------------------|-------------------------------------|--|----------|----------|----------|-------------------|---------------|---------------|-----------------|---------------|-----------------|--------------|----------------|----------------------|------------------------|----------------------|----------------------|-------------------------|-----------------------------|------------------------------|-----------------------------|-------------------|-----------------------|---------------|-------------------|---------------|-------------------|---------------|---------------|---------------|--------------------------|
|                                     |                                     | Tenant 4   | Tenant 3 | Tenant 2 | Tenant 1 | Tenant (Director) | Tenant (APWO) | Owner 1 (UEM) | Owner 2 (UEM-J) | Owner 3 (UEM) | Owner 4 (UEM-T) | Owner 5 (AM) | Owner 5 (AM-A) | Facility Mgr. 1 (CM) | Facility Mgr. 2 (CM-J) | Facility Mgr. 3 (EE) | Facility Mgr. 4 (ME) | Facility Mgr. 5 (Maint) | Facility Mgr. 6 (Maint - R) | Facility Mgr. 7 (Maint - K1) | Facility Mgr. 8 (Maint - K) | Designer (ME - B) | Designer 2 (ME - Byd) | Designer (ME) | Designer (ME - T) | Designer (PM) | Designer (PM - A) | Designer (CE) | Designer (TL) | Environmental | Environmental 2 (EV - S) |
| 1                                   | Reduce energy costs                 | 20   | 45       | 25       | 20       | 15                | 5             | 5             | 5               | 5             | 5               | 25           | 15             | 15                   | 15                     | 45                   | 45                   | 5                       | 5                           | 25                           | 20                          | 15                | 0                     | 0             | 15                | 45            | 9                 | 15            | 5             | 25            | 25                       |
| 2                                   | Increase return on investment       | 0  | 5        | 0        | 0        | 4                 | 5             | 0             | 0               | 5             | 0               | 0            | 15             | 15                   | 20                     | 20                   | 20                   | 0                       | 0                           | 0                            | 5                           | 0                 | 0                     | 0             | 0                 | 5             | 0                 | 0             | 4             | 12            | 12                       |
| 3                                   | Minimize environmental impact       | 27   | 36       | 27       | 36       | 27                | 20            | 20            | 15              | 20            | 15              | 27           | 27             | 36                   | 36                     | 27                   | 45                   | 36                      | 15                          | 36                           | 36                          | 15                | 15                    | 20            | 10                | 36            | 20                | 12            | 9             | 25            | 20                       |
| 4                                   | Improve your organization's image   | 12   | 4        | 27       | 27       | 27                | 2             | 15            | 0               | 0             | 15              | 25           | 25             | 15                   | 15                     | 27                   | 45                   | 3                       | 0                           | 0                            | 6                           | 10                | 10                    | 6             | 4                 | 0             | 6                 | 9             | 9             | 15            | 15                       |
| 5                                   | Improve occupant comfort            | 9  | 20       | 12       | 15       | 3                 | 3             | -4            | 3               | 12            | 12              | 4            | 3              | 12                   | 12                     | 4                    | 12                   | 3                       | 0                           | 0                            | 0                           | 0                 | 0                     | 0             | 0                 | 20            | 4                 | 0             | 4             | 9             | 3                        |
| 6                                   | Increase energy efficiency          | 20   | 25       | 45       | 45       | 36                | 5             | 25            | 15              | 25            | 15              | 15           | 25             | 45                   | 45                     | 25                   | 45                   | 0                       | 45                          | 36                           | 4                           | 4                 | 9                     | 9             | 25                | 20            | 12                | 4             | 20            | 12            |                          |
| 7                                   | Increase carbon neutrality          | 15   | 27       | 36       | 18       | 18                | 1             | 10            | 18              | 9             | 5               | 9            | 18             | 18                   | 9                      | 45                   | 15                   | 9                       | 27                          | 0                            | 3                           | 0                 | 27                    | 15            | 6                 | 6             | 15                | 6             | 15            | 15            |                          |
| 8                                   | Achieve lower total ownership costs | 4  | 5        | 12       | 15       | 15                | 4             | 5             | 4               | 4             | 4               | 5            | 25             | 25                   | 20                     | 4                    | 4                    | 0                       | 0                           | 0                            | 0                           | 15                | 9                     | 5             | 0                 | 5             | 0                 | 5             | 5             |               |                          |
| 9                                   | Meet regulatory requirements        | 20   | 15       | 10       | 20       | 25                | 12            | 25            | 3               | 3             | 25              | 20           | 25             | 15                   | 15                     | 45                   | 45                   | 20                      | 15                          | 27                           | 36                          | 15                | 20                    | 12            | 9                 | 15            | 5                 | 12            | 20            | 45            |                          |
| 10                                  | Comply with policy or legislation   | 20   | 25       | 25       | 25       | 12                | 15            | 3             | 5               | 25            | 15              | 15           | 25             | 25                   | 25                     | 45                   | 45                   | 25                      | 15                          | 25                           | 25                          | 20                | 20                    | 9             | 25                | 5             | 12                | 20            | 25            | 25            |                          |
| 11                                  | Improve aesthetic quality of site   | 10   | 27       | 10       | 20       | 20                | 2             | 0             | 0               | 2             | 0               | 0            | 9              | 6                    | 6                      | 2                    | 6                    | 6                       | 0                           | 3                            | 3                           | 6                 | 0                     | 0             | 3                 | 27            | 0                 | 1             | 3             | 6             | 2                        |
| 12                                  | Improve occupant productivity       | 12   | 25       | 15       | 25       | 25                | 2             | 0             | 4               | 4             | 9               | 9            | 9              | 9                    | 9                      | 4                    | 15                   | 12                      | 4                           | 4                            | 4                           | 0                 | 0                     | 0             | 0                 | 20            | 3                 | 3             | 4             | 4             |                          |
| 13                                  | Reduce chance of opposition         | 12   | 10       | 6        | 9        | 9                 | 2             | 0             | 0               | 3             | 9               | 9            | 15             | 15                   | 12                     | 36                   | 15                   | 15                      | 3                           | 0                            | 3                           | 9                 | 6                     | 3             | 5                 | 0             | 3                 | 6             | 20            | 20            |                          |
| 14                                  | Increase property value             | 12   | 0        | 6        | 6        | 6                 | 1             | 0             | 0               | 0             | 3               | 3            | 5              | 3                    | 3                      | 2                    | 3                    | 6                       | 3                           | 0                            | 0                           | 0                 | 3                     | 2             | 0                 | 0             | 0                 | 0             | 0             | 3             | 0                        |
| 15                                  | Reduce energy consumption           | 20   | 45       | 45       | 45       | 36                | 5             | 25            | 5               | 5             | 25              | 15           | 15             | 25                   | 25                     | 25                   | 45                   | 25                      | 0                           | 45                           | 45                          | 9                 | 4                     | 4             | 9                 | 45            | 20                | 15            | 25            | 20            | 12                       |
| 16                                  | Provide a secure energy supply      | 9  | 36       | 36       | 27       | 45                | 12            | 5             | 0               | 0             | 2               | 9            | 6              | 0                    | 0                      | 2                    | 3                    | 15                      | 0                           | 36                           | 27                          | 3                 | 3                     | 0             | 0                 | 36            | 0                 | 0             | 0             | 36            | 4                        |
| 17                                  | Facilitate renewable energy         | 20   | 36       | 36       | 18       | 18                | 3             | 15            | 10              | 10            | 10              | 15           | 10             | 20                   | 20                     | 25                   | 45                   | 10                      | 9                           | 18                           | 18                          | 27                | 27                    | 6             | 6                 | 36            | 10                | 12            | 20            | 9             |                          |
| 18                                  | Lower project capital costs         | 0  | 0        | 0        | 0        | 4                 | 20            | 0             | 0               | 0             | 20              | 12           | 15             | 0                    | 12                     | 15                   | 9                    | 9                       | 12                          | 0                            | 0                           | 4                 | 4                     | 0             | 0                 | 0             | 0                 | 0             | 0             | 4             | 4                        |
| 19                                  | Reduce costs of carbon offset       | 27   | 36       | 27       | 27       | 36                | 3             | 5             | 5               | 2             | 6               | 6            | 5              | 10                   | 2                      | 45                   | 10                   | 6                       | 27                          | 36                           | 9                           | 9                 | 3                     | 3             | 36                | 6             | 3                 | 6             | 3             | 3             |                          |
| 20                                  | Achieve higher rental rates         | 0  | 0        | 0        | 0        | 1                 | 0             | 0             | 3               | 3             | 1               | 4            | 3              | 0                    | 3                      | 0                    | 3                    | 6                       | 1                           | 2                            | 2                           | 1                 | 3                     | 0             | 0                 | 0             | 0                 | 0             | 0             | 0             | 0                        |
| 21                                  | Achieve higher occupancy rates      | 0  | 0        | 9        | 3        | 3                 | 1             | 3             | 2               | 2             | 3               | 3            | 5              | 1                    | 0                      | 9                    | 9                    | 2                       | 0                           | 0                            | 0                           | 0                 | 0                     | 0             | 0                 | 0             | 0                 | 0             | 0             | 0             | 0                        |
| 22                                  | Avoid costs due to opposition       | 12   | 10       | 15       | 10       | 20                | 2             | 3             | 1               | 2             | 6               | 9            | 9              | 9                    | 9                      | 12                   | 12                   | 15                      | 3                           | 3                            | 6                           | 9                 | 3                     | 3             | 5                 | 0             | 6                 | 6             | 9             | 4             |                          |
| 23                                  | Gain the public's trust             | 12   | 20       | 20       | 20       | 20                | 0             | 15            | 15              | 15            | 3               | 3            | 25             | 25                   | 9                      | 15                   | 12                   | 6                       | 0                           | 0                            | 6                           | 10                | 15                    | 9             | 20                | 0             | 9                 | 9             | 12            | 12            |                          |
| 24                                  | Decrease outages / interruptions    | 12   | 0        | 5        | 5        | 4                 | 4             | 0             | 0               | 3             | 0               | 0            | 0              | 5                    | 5                      | 9                    | 12                   | 0                       | 0                           | 0                            | 0                           | 0                 | 0                     | 0             | 0                 | 0             | 0                 | 0             | 0             | 0             |                          |
| 25                                  | Attract and retain employees        | 12   | 20       | 4        | 3        | 3                 | 1             | 9             | 0               | 0             | 9               | 12           | 12             | 12                   | 12                     | 25                   | 12                   | 12                      | 2                           | 3                            | 0                           | 2                 | 2                     | 0             | 20                | 0             | 0                 | 2             | 1             | 1             |                          |
| 26                                  | Improve occupant attendance         | 12   | 15       | 4        | 5        | 5                 | 2             | 2             | 2               | 3             | 3               | 0            | 0              | 6                    | 25                     | 25                   | 0                    | 0                       | 0                           | 0                            | 0                           | 0                 | 0                     | 0             | 0                 | 9             | 2                 | 0             | 0             | 0             |                          |
| 27                                  | Improve occupant health             | 12   | 20       | 4        | 5        | 5                 | 4             | 0             | 0               | 2             | 4               | 4            | 15             | 20                   | 10                     | 25                   | 6                    | 9                       | 0                           | 0                            | 0                           | 0                 | 0                     | 0             | 20                | 12            | 0                 | 0             | 15            | 15            |                          |
| 28                                  | Improve corporate reporting results | 3  | 45       | 15       | 12       | 9                 | 12            | 12            | 3               | 4             | 2               | 4            | 4              | 12                   | 12                     | 6                    | 12                   | 25                      | 15                          | 9                            | 9                           | 0                 | 0                     | 0             | 45                | 0             | 20                | 15            | 15            | 15            |                          |
| 29                                  | Diversify investment portfolios     | 0  | 3        | 2        | 1        | 1                 | 1             | 0             | 0               | 1             | 2               | 0            | 0              | 0                    | 0                      | 18                   | 36                   | 6                       | 6                           | 0                            | 0                           | 0                 | 0                     | 0             | 3                 | 0             | 0                 | 0             | 1             | 0             | 0                        |
| 30                                  | Leverage business platforms         | 4  | 0        | 5        | 4        | 1                 | 4             | 0             | 0               | 2             | 2               | 4            | 3              | 0                    | 12                     | 12                   | 15                   | 15                      | 10                          | 0                            | 0                           | 0                 | 0                     | 0             | 0                 | 0             | 0                 | 0             | 3             | 12            | 9                        |

**Table 42 – Environmental Considerations Technical Importance Rating Summary and Data Analysis Calculations, by Stakeholder Group**

| Potential Stakeholder Requirements: |                                     | Environmental Impact - Technical Importance |           |          |         |           |          |               |           |          |           |           |          |              |           |          |               |           |          |
|-------------------------------------|-------------------------------------|---|-----------|----------|---------|-----------|----------|---------------|-----------|----------|-----------|-----------|----------|--------------|-----------|----------|---------------|-----------|----------|
|                                     |                                     | Tenant                                      |           |          | Owner   |           |          | Facility Mgr. |           |          | Designers |           |          | Environmntl. |           |          | Weighted Avg. |           |          |
|                                     |                                     | Average                                     | Std. Dev. | Variance | Average | Std. Dev. | Variance | Average       | Std. Dev. | Variance | Average   | Std. Dev. | Variance | Average      | Std. Dev. | Variance | Average       | Std. Dev. | Variance |
| 1                                   | Reduce energy costs                 | 25  | 9.6       | 92       | 10      | 7.6       | 58       | 21.9          | 15        | 218      | 13.6      | 14        | 205      | 25           | 0         | 0        | 19.1          | 6.18      | 38.1     |
| 2                                   | Increase return on investment       | 1.5   | 2.1       | 4.6      | 1.67    | 2.4       | 5.6      | 9.38          | 8.5       | 71       | 1.29      | 2.1       | 4.2      | 12           | 0         | 0        | 5.17          | 4.59      | 21       |
| 3                                   | Minimize environmental impact       | 28.8  | 5.6       | 32       | 20.7    | 4.9       | 24       | 33.4          | 8.3       | 68       | 16.7      | 8.6       | 74       | 22.5         | 2.5       | 6.3      | 24.4          | 5.95      | 35.4     |
| 4                                   | Improve your organization's image   | 16.5  | 11        | 120      | 13.3    | 10        | 106      | 13.5          | 15        | 221      | 7.29      | 2.2       | 4.8      | 12           | 3         | 9        | 12.5          | 3         | 9.03     |
| 5                                   | Improve occupant comfort            | 12.3  | 5.3       | 29       | 3.67    | 6.5       | 43       | 7.75          | 4.3       | 18       | 3.43      | 6.9       | 48       | 6            | 3         | 9        | 6.64          | 3.26      | 10.6     |
| 6                                   | Increase energy efficiency          | 29.3  | 14        | 206      | 18.3    | 4.7       | 22       | 27.6          | 18        | 314      | 9.57      | 6.9       | 48       | 16           | 4         | 16       | 20.2          | 7.38      | 54.5     |
| 7                                   | Increase carbon neutrality          | 19.2  | 11        | 116      | 10      | 3.9       | 15       | 18.8          | 11        | 132      | 6.43      | 8.7       | 76       | 15           | 0         | 0        | 13.9          | 4.97      | 24.7     |
| 8                                   | Achieve lower total ownership costs | 9.17  | 4.9       | 24       | 4.5     | 0.5       | 0.3      | 12.9          | 11        | 123      | 5.57      | 4.8       | 23       | 5            | 0         | 0        | 7.42          | 3.18      | 10.1     |
| 9                                   | Meet regulatory requirements        | 17  | 5.2       | 27       | 16.8    | 9.9       | 99       | 27.3          | 12        | 151      | 14.7      | 3.8       | 15       | 45           | 0         | 0        | 24.2          | 11.3      | 128      |
| 10                                  | Comply with policy or legislation   | 22  | 4.8       | 23       | 13      | 7.3       | 53       | 28.8          | 9.9       | 98       | 16.4      | 5.9       | 35       | 25           | 0         | 0        | 21            | 5.69      | 32.4     |
| 11                                  | Improve aesthetic quality of site   | 14.8  | 8.3       | 69       | 0.67    | 0.9       | 0.9      | 4.38          | 2.7       | 7.2      | 5.71      | 8.9       | 79       | 4            | 2         | 4        | 5.92          | 4.76      | 22.6     |
| 12                                  | Improve occupant productivity       | 17.3  | 8.6       | 74       | 4.33    | 3.7       | 14       | 7.63          | 4         | 16       | 3.71      | 6.8       | 46       | 4            | 0         | 0        | 7.4           | 5.16      | 26.7     |
| 13                                  | Reduce chance of opposition         | 8   | 3.2       | 10       | 5       | 4.1       | 17       | 13.9          | 10        | 101      | 5         | 2.1       | 4.3      | 20           | 0         | 0        | 10.4          | 5.8       | 33.7     |
| 14                                  | Increase property value             | 5.17  | 3.9       | 15       | 1.83    | 2         | 3.8      | 2.5           | 1.8       | 3.3      | 0.71      | 1.2       | 1.3      | 1.5          | 1.5       | 2.3      | 2.34          | 1.52      | 2.32     |
| 15                                  | Reduce energy consumption           | 32.7  | 15        | 232      | 15      | 8.2       | 67       | 29.4          | 14        | 209      | 15.9      | 14        | 187      | 16           | 4         | 16       | 21.8          | 7.62      | 58.1     |
| 16                                  | Provide a secure energy supply      | 27.5  | 13        | 172      | 3.67    | 3.3       | 11       | 10.4          | 13        | 175      | 6         | 12        | 152      | 20           | 16        | 256      | 13.5          | 8.95      | 80.2     |
| 17                                  | Facilitate renewable energy         | 21.8  | 11        | 131      | 12.5    | 2.5       | 6.3      | 20.6          | 10        | 109      | 18        | 11        | 121      | 14.5         | 5.5       | 30       | 17.5          | 3.54      | 12.6     |
| 18                                  | Lower project capital costs         | 0.67  | 1.5       | 2.2      | 11.2    | 8.4       | 70       | 7.13          | 5.8       | 34       | 1.14      | 1.8       | 3.3      | 4            | 0         | 0        | 4.82          | 3.93      | 15.4     |
| 19                                  | Reduce costs of carbon offset       | 26  | 11        | 122      | 4.33    | 1.7       | 2.9      | 17.6          | 15        | 229      | 9.86      | 11        | 120      | 3            | 0         | 0        | 12.2          | 8.62      | 74.4     |
| 20                                  | Achieve higher rental rates         | 0.17  | 0.4       | 0.1      | 1.83    | 1.6       | 2.5      | 2.25          | 1.7       | 2.9      | 0.57      | 1         | 1.1      | 0            | 0         | 0        | 0.96          | 0.91      | 0.83     |
| 21                                  | Achieve higher occupancy rates      | 2.67  | 3.1       | 9.6      | 3       | 1         | 1        | 2.88          | 3.6       | 13       | 0         | 0         | 0        | 0            | 0         | 0        | 1.71          | 1.4       | 1.96     |
| 22                                  | Avoid costs due to opposition       | 11.5  | 5.5       | 30       | 5       | 3.2       | 10       | 9.75          | 4.4       | 20       | 5.43      | 1.9       | 3.7      | 6.5          | 2.5       | 6.3      | 7.64          | 2.55      | 6.5      |
| 23                                  | Gain the public's trust             | 15.3  | 7.5       | 56       | 11      | 5.7       | 32       | 11.5          | 9.2       | 85       | 11.1      | 4.4       | 19       | 12           | 0         | 0        | 12.2          | 1.61      | 2.58     |
| 24                                  | Decrease outages / interruptions    | 5.17  | 3.5       | 12       | 1.17    | 1.7       | 2.8      | 3.88          | 4.4       | 19       | 0         | 0         | 0        | 0            | 0         | 0        | 2.04          | 2.11      | 4.45     |
| 25                                  | Attract and retain employees        | 7.17  | 6.7       | 45       | 7       | 5.1       | 26       | 12.9          | 8         | 64       | 3.71      | 6.7       | 45       | 1            | 0         | 0        | 6.35          | 3.98      | 15.8     |
| 26                                  | Improve occupant attendance         | 7.17  | 4.7       | 22       | 1.67    | 1.2       | 1.6      | 8.13          | 10        | 105      | 1.29      | 3.1       | 9.9      | 0            | 0         | 0        | 3.65          | 3.32      | 11       |
| 27                                  | Improve occupant health             | 8.33  | 5.9       | 35       | 2       | 1.6       | 2.7      | 10.6          | 8.4       | 70       | 2.86      | 7         | 49       | 15           | 0         | 0        | 7.76          | 4.86      | 23.6     |
| 28                                  | Improve corporate reporting results | 16  | 13        | 182      | 4.83    | 3.3       | 11       | 12.5          | 5.4       | 29       | 11.4      | 16        | 248      | 15           | 0         | 0        | 12            | 3.92      | 15.4     |
| 29                                  | Diversify investment portfolios     | 1.33  | 0.9       | 0.9      | 0.5     | 0.8       | 0.6      | 8.25          | 12        | 143      | 0.57      | 1         | 1.1      | 0            | 0         | 0        | 2.13          | 3.09      | 9.54     |
| 30                                  | Leverage business platforms         | 3   | 1.8       | 3.3      | 1.83    | 1.5       | 2.1      | 6.75          | 6.8       | 47       | 0.43      | 1         | 1.1      | 10.5         | 1.5       | 2.3      | 4.5           | 3.66      | 13.4     |
| S                                   | Minimum                             | 0.2   |           |          | 0.5     |           |          | 2.3           |           |          | 0.0       |           |          | 0.0          |           |          | 1.0           |           |          |
| T                                   | 1st Quartile (lower 25%)            | 5.7   |           |          | 1.9     |           |          | 7.7           |           |          | 1.3       |           |          | 3.3          |           |          | 4.9           |           |          |
| A                                   | Median                              | 13.6  |           |          | 4.7     |           |          | 11.1          |           |          | 5.5       |           |          | 11.3         |           |          | 7.7           |           |          |
| T                                   | 3rd Quartile (upper 25%)            | 21.2  |           |          | 11.1    |           |          | 18.5          |           |          | 10.8      |           |          | 15.8         |           |          | 13.8          |           |          |
| S                                   | Maximum                             | 32.7  |           |          | 20.7    |           |          | 33.4          |           |          | 18.0      |           |          | 45.0         |           |          | 24.4          |           |          |

**Appendix I – HOQ Economic Sustainability Considerations Relationship  
Data, Technical Importance Calculations, and Data Analysis Calculations**

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**Table 43 – Economic Considerations, Relationship Rating Survey Data: HOQ Survey  
Individual Participant Responses**

| Potential Stakeholder Requirements:    | Economic Impact Vs. Stakeholder Requirements - Relationship Rating Data |          |          |          |                   |               |                 |               |                 |              |                |                      |                        |                      |                      |                         |                             |                              |                             |                   |                       |               |                   |               |                   |               |               |               |                          |   |
|--|---|----------|----------|----------|-------------------|---------------|-----------------|---------------|-----------------|--------------|----------------|----------------------|------------------------|----------------------|----------------------|-------------------------|-----------------------------|------------------------------|-----------------------------|-------------------|-----------------------|---------------|-------------------|---------------|-------------------|---------------|---------------|---------------|--------------------------|---|
|  | Tenant 4  | Tenant 3 | Tenant 2 | Tenant 1 | Tenant (Director) | Owner 1 (UEM) | Owner 2 (UEM-J) | Owner 3 (UEM) | Owner 4 (UEM-T) | Owner 5 (AM) | Owner 5 (AM-A) | Facility Mgr. 1 (CM) | Facility Mgr. 2 (CM-J) | Facility Mgr. 3 (EE) | Facility Mgr. 4 (ME) | Facility Mgr. 5 (Maint) | Facility Mgr. 6 (Maint - R) | Facility Mgr. 7 (Maint - K1) | Facility Mgr. 8 (Maint - K) | Designer (ME - B) | Designer 2 (ME - Byd) | Designer (ME) | Designer (ME - T) | Designer (PM) | Designer (PM - A) | Designer (CE) | Designer (TL) | Environmental | Environmental 2 (EV - S) |   |
| 1 Reduce energy costs                  | 5   | 9        | 9        | 5        | 5                 | 9             | 9               | 9             | 9               | 9            | 9              | 9                    | 9                      | 9                    | 9                    | 9                       | 9                           | 9                            | 9                           | 9                 | 9                     | 9             | 9                 | 9             | 9                 | 9             | 9             | 9             | 9                        | 9 |
| 2 Increase return on investment        | 5   | 9        | 9        | 5        | 5                 | 9             | 9               | 9             | 9               | 9            | 9              | 9                    | 9                      | 9                    | 9                    | 9                       | 9                           | 9                            | 9                           | 9                 | 9                     | 9             | 9                 | 9             | 9                 | 9             | 9             | 9             | 9                        | 9 |
| 3 Minimize environmental impact        | 3   | 1        | 1        | 3        | 3                 | 3             | 3               | 1             | 1               | 1            | 1              | 1                    | 1                      | 1                    | 5                    | 3                       | 1                           | 3                            | 3                           | 1                 | 1                     | 0             | 0                 | 3             | 3                 | 9             | 5             | 3             | 5                        | 5 |
| 4 Improve your organization's image    | 9   | 5        | 1        | 9        | 9                 | 1             | -1              | 5             | 5               | 3            | 3              | 9                    | 9                      | 5                    | 9                    | 5                       | 1                           | 5                            | 5                           | 1                 | 1                     | 3             | 3                 | 5             | 3                 | 3             | 3             | 3             | 3                        | 3 |
| 5 Improve occupant comfort             | 3   | 1        | 1        | 3        | 3                 | 1             | -1              | 5             | 5               | 1            | 1              | 3                    | 3                      | 5                    | 5                    | 3                       | 1                           | 5                            | 5                           | 1                 | 1                     | 3             | 3                 | 1             | 3                 | 3             | 5             | 3             | 3                        | 3 |
| 6 Increase energy efficiency           | 9   | 9        | 9        | 9        | 5                 | 5             | 9               | 9             | 9               | 9            | 9              | 9                    | 9                      | 9                    | 9                    | 9                       | 9                           | 9                            | 9                           | 9                 | 9                     | 9             | 9                 | 9             | 9                 | 9             | 9             | 9             | 9                        | 9 |
| 7 Increase carbon neutrality           | 3   | 1        | 5        | 3        | 3                 | 1             | -1              | 5             | 5               | 0            | 0              | 3                    | 3                      | 5                    | 3                    | 3                       | 1                           | 1                            | 0                           | 0                 | 3                     | 3             | 1                 | 0             | 3                 | 1             | 0             | 3             | 1                        | 1 |
| 8 Achieve lower total ownership costs  | 5   | 9        | 9        | 5        | 5                 | 1             | 9               | 9             | 5               | 9            | 9              | 9                    | 9                      | 5                    | 9                    | 9                       | 9                           | 9                            | 9                           | 9                 | 9                     | 9             | 9                 | 9             | 9                 | 9             | 9             | 9             | 9                        | 9 |
| 9 Meet regulatory requirements         | 5   | 3        | 1        | 5        | 5                 | 1             | -1              | 5             | 5               | 3            | 3              | 3                    | 3                      | 5                    | 9                    | 3                       | 1                           | 1                            | 1                           | 3                 | 3                     | 0             | 0                 | 3             | 3                 | 0             | 3             | 0             | 5                        | 0 |
| 10 Comply with policy or legislation   | 5   | 5        | 3        | 5        | 5                 | 3             | 1               | 1             | 5               | 5            | 1              | 5                    | 5                      | 5                    | 9                    | 3                       | 1                           | 5                            | 1                           | 3                 | 3                     | 0             | 0                 | 5             | 3                 | 0             | 3             | 0             | 3                        | 5 |
| 11 Improve aesthetic quality of site   | -1  | -1       | -1       | -1       | -1                | 1             | -1              | -1            | 1               | 1            | 1              | 3                    | 3                      | 1                    | 3                    | 1                       | 1                           | 1                            | 1                           | 3                 | 3                     | 5             | 5                 | -1            | 3                 | 3             | 3             | 3             | 5                        | 9 |
| 12 Improve occupant productivity       | 9   | 5        | -1       | 9        | 9                 | 1             | 1               | 1             | 3               | 5            | 9              | 9                    | 9                      | 3                    | 9                    | 3                       | 3                           | 9                            | 9                           | 3                 | 3                     | 3             | 3                 | 5             | 1                 | 0             | 0             | 5             | 5                        |   |
| 13 Reduce chance of opposition         | 9   | 1        | 1        | 9        | 9                 | 1             | -1              | 5             | 5               | 3            | 3              | 3                    | 3                      | 5                    | 9                    | 3                       | 1                           | 5                            | 5                           | 3                 | 3                     | 3             | 3                 | 1             | 1                 | 3             | 0             | 5             | 5                        |   |
| 14 Increase property value             | 5   | 9        | 9        | 5        | 5                 | 1             | 1               | 5             | 5               | 9            | 9              | 5                    | 5                      | 5                    | 9                    | 3                       | 3                           | 9                            | 9                           | 5                 | 5                     | 3             | 3                 | 9             | 5                 | 3             | 9             | 5             | 3                        | 9 |
| 15 Reduce energy consumption           | 5   | 9        | 9        | 5        | 5                 | 5             | 9               | 9             | 5               | 5            | 5              | 5                    | 5                      | 5                    | 9                    | 9                       | 9                           | 9                            | 9                           | 9                 | 9                     | 9             | 9                 | 9             | 9                 | 9             | 9             | 9             | 9                        | 9 |
| 16 Provide a secure energy supply      | 9   | 9        | 9        | 9        | 3                 | -1            | -1              | 5             | 5               | 1            | 1              | 1                    | 1                      | 5                    | 3                    | 9                       | 0                           | 5                            | 5                           | 1                 | 1                     | 3             | 3                 | 9             | 3                 | 9             | 3             | 3             | 5                        | 1 |
| 17 Facilitate renewable energy         | 3   | 9        | 5        | 3        | 3                 | 1             | -1              | -1            | 5               | 3            | 3              | 5                    | 5                      | 5                    | 9                    | 5                       | 3                           | 3                            | 1                           | 1                 | 1                     | 1             | 1                 | 9             | 1                 | 3             | 3             | 5             | 1                        |   |
| 18 Lower project capital costs         | 9   | 9        | 9        | 9        | 1                 | 5             | 5               | 5             | 5               | 9            | 9              | 9                    | 9                      | 5                    | 9                    | 9                       | 9                           | 9                            | 9                           | 9                 | 9                     | 9             | 9                 | 9             | 9                 | 9             | 9             | 9             | 9                        | 9 |
| 19 Reduce costs of carbon offset       | 5   | 3        | 1        | 5        | 5                 | 1             | -1              | 5             | 5               | 5            | 3              | 3                    | 3                      | 5                    | 9                    | 3                       | 3                           | 3                            | 3                           | -1                | -1                    | 3             | 3                 | 3             | 1                 | 3             | 3             | 5             | 5                        |   |
| 20 Achieve higher rental rates         | 5   | 9        | 5        | 5        | 5                 | 1             | 5               | 1             | 5               | 9            | 9              | 3                    | 3                      | 5                    | 9                    | 5                       | 0                           | 9                            | 9                           | 9                 | 9                     | 9             | 9                 | 9             | 9                 | 9             | 9             | 9             | 9                        | 9 |
| 21 Achieve higher occupancy rates      | 5   | 3        | 9        | 5        | 5                 | 1             | 1               | 5             | 5               | 9            | 9              | 3                    | 3                      | 5                    | 9                    | 3                       | 0                           | 9                            | 9                           | 5                 | 5                     | 3             | 3                 | 3             | 3                 | 3             | 3             | 3             | 3                        | 5 |
| 22 Avoid costs due to opposition       | 9   | 3        | 1        | 9        | 9                 | 1             | -1              | 5             | 5               | 3            | 3              | 3                    | 3                      | 5                    | 5                    | 1                       | 1                           | 5                            | 5                           | 5                 | 5                     | 3             | 3                 | 3             | 1                 | 3             | 3             | 3             | 5                        | 5 |
| 23 Gain the public's trust             | 9   | 5        | 5        | 9        | 9                 | 1             | 1               | 5             | 1               | 3            | 3              | 3                    | 3                      | 1                    | 5                    | 3                       | 3                           | 5                            | 5                           | 0                 | 0                     | 3             | 3                 | 5             | 3                 | 1             | 1             | 5             | 3                        | 3 |
| 24 Decrease outages / interruptions    | 9   | 9        | 5        | 9        | 9                 | 1             | 1               | 1             | 1               | 5            | 1              | 5                    | 5                      | 5                    | 9                    | 1                       | 1                           | 5                            | 5                           | 1                 | 1                     | 1             | 1                 | 1             | 9                 | 1             | 3             | 3             | 5                        | 3 |
| 25 Attract and retain employees        | 5   | 5        | 5        | 5        | 5                 | 1             | 0               | 0             | 3               | 3            | 5              | 5                    | 5                      | 3                    | 9                    | 3                       | 3                           | 9                            | 9                           | 3                 | 3                     | 3             | 3                 | 3             | 5                 | 3             | 3             | 1             | 3                        | 3 |
| 26 Improve occupant attendance         | 9   | 9        | 5        | 9        | 9                 | 1             | 0               | 0             | 3               | 3            | 3              | 3                    | 3                      | 3                    | 5                    | 0                       | 0                           | 9                            | 9                           | 3                 | 3                     | 3             | 3                 | 9             | 1                 | 1             | 1             | 3             | 3                        |   |
| 27 Improve occupant health             | 5   | 5        | 5        | 5        | 5                 | 3             | 1               | 0             | 1               | 1            | 3              | 3                    | 5                      | 1                    | 9                    | 3                       | 3                           | 5                            | 5                           | 1                 | 1                     | 3             | 3                 | 5             | 3                 | 1             | 1             | 3             | 3                        | 3 |
| 28 Improve corporate reporting results | 5   | 5        | 5        | 5        | 5                 | 3             | 0               | 0             | 5               | 9            | 9              | 3                    | 3                      | 5                    | 9                    | 5                       | 9                           | 9                            | 5                           | 5                 | 0                     | 0             | 5                 | 0             | 5                 | 3             | 5             | 5             | 5                        | 5 |
| 29 Diversify investment portfolios     | 3   | 9        | 9        | 3        | 3                 | 1             | 1               | 1             | 1               | 5            | 5              | 3                    | 0                      | 0                    | 5                    | 9                       | 3                           | 9                            | 9                           | 3                 | 3                     | 0             | 0                 | 9             | 3                 | 3             | 3             | 5             | 5                        | 5 |
| 30 Leverage business platforms         | 5   | 9        | 9        | 5        | 5                 | 1             | 1               | 1             | 5               | 3            | 3              | 0                    | 0                      | 5                    | 9                    | 3                       | 3                           | 9                            | 9                           | 5                 | 5                     | 0             | 0                 | 9             | 3                 | 3             | 3             | 5             | 5                        | 5 |

**Table 44 – Economic Considerations Technical Importance Calculations: Results for each Individual Participant**

| Potential Stakeholder Requirements: |                                     | Economic Impact - Summary of Technical Importance |          |          |          |                   |               |               |                 |               |                 |              |                |                      |                        |                      |                      |                         |                             |                              |                             |                   |                       |               |                 |               |                   |               |               |               |                          |
|-------------------------------------|-------------------------------------|---|----------|----------|----------|-------------------|---------------|---------------|-----------------|---------------|-----------------|--------------|----------------|----------------------|------------------------|----------------------|----------------------|-------------------------|-----------------------------|------------------------------|-----------------------------|-------------------|-----------------------|---------------|-----------------|---------------|-------------------|---------------|---------------|---------------|--------------------------|
|                                     |                                     | Tenant 4  | Tenant 3 | Tenant 2 | Tenant 1 | Tenant (Director) | Tenant (APWO) | Owner 1 (UEM) | Owner 2 (UEM-J) | Owner 3 (UEM) | Owner 4 (UEM-T) | Owner 5 (AM) | Owner 5 (AM-A) | Facility Mgr. 1 (CM) | Facility Mgr. 2 (CM-J) | Facility Mgr. 3 (EE) | Facility Mgr. 4 (ME) | Facility Mgr. 5 (Maint) | Facility Mgr. 6 (Maint - R) | Facility Mgr. 7 (Maint - K1) | Facility Mgr. 8 (Maint - K) | Designer (ME - B) | Designer 2 (ME - Byd) | Designer (ME) | Designer (ME-T) | Designer (PM) | Designer (PM - A) | Designer (CE) | Designer (TL) | Environmental | Environmental 2 (EV - S) |
| 1                                   | Reduce energy costs                 | 20  | 45       | 25       | 20       | 25                | 45            | 45            | 45              | 45            | 45              | 45           | 45             | 45                   | 45                     | 45                   | 45                   | 25                      | 25                          | 45                           | 36                          | 25                | 25                    | 15            | 15              | 45            | 15                | 45            | 15            | 45            | 45                       |
| 2                                   | Increase return on investment       | 20  | 45       | 25       | 25       | 20                | 45            | 45            | 45              | 45            | 45              | 45           | 45             | 45                   | 45                     | 36                   | 45                   | 45                      | 45                          | 45                           | 45                          | 0                 | 0                     | 15            | 15              | 45            | 20                | 12            | 20            | 20            |                          |
| 3                                   | Minimize environmental impact       | 9   | 4        | 3        | 12       | 9                 | 12            | 9             | 4               | 3             | 3               | 3            | 4              | 4                    | 3                      | 25                   | 12                   | 3                       | 12                          | 12                           | 3                           | 3                 | 0                     | 0             | 4               | 4             | 0                 | 9             | 15            | 12            |                          |
| 4                                   | Improve your organization's image   | 36  | 20       | 3        | 27       | 27                | 2             | -3            | -3              | 15            | 15              | 15           | 15             | 27                   | 27                     | 15                   | 45                   | 15                      | 3                           | 10                           | 15                          | 2                 | 2                     | 6             | 6               | 20            | 9                 | 6             | 9             | 15            | 9                        |
| 5                                   | Improve occupant comfort            | 9   | 4        | 4        | 15       | 15                | 3             | -3            | -4              | 20            | 15              | 4            | 4              | 12                   | 9                      | 20                   | 12                   | 4                       | 20                          | 15                           | 2                           | 2                 | 9                     | 9             | 4               | 12            | 12                | 20            | 9             | 9             |                          |
| 6                                   | Increase energy efficiency          | 36  | 45       | 45       | 45       | 36                | 25            | 45            | 25              | 45            | 45              | 45           | 45             | 45                   | 45                     | 45                   | 45                   | 45                      | 45                          | 45                           | 36                          | 20                | 3                     | 3             | 45              | 12            | 20                | 20            | 12            |               |                          |
| 7                                   | Increase carbon neutrality          | 9   | 3        | 20       | 6        | 6                 | 1             | -2            | -2              | 5             | 0               | 4            | 6              | 6                    | 6                      | 5                    | 15                   | 9                       | 3                           | 1                            | 3                           | 0                 | 3                     | 0             | 3               | 0             | 6                 | 2             | 3             | 3             |                          |
| 8                                   | Achieve lower total ownership costs | 20  | 45       | 36       | 25       | 25                | 4             | 45            | 36              | 20            | 45              | 45           | 45             | 45                   | 45                     | 25                   | 36                   | 20                      | 20                          | 45                           | 36                          | 45                | 36                    | 5             | 3               | 45            | 20                | 5             | 45            | 25            | 25                       |
| 9                                   | Meet regulatory requirements        | 20  | 9        | 2        | 20       | 25                | 4             | -5            | -3              | 15            | 25              | 15           | 15             | 15                   | 15                     | 25                   | 45                   | 12                      | 5                           | 3                            | 4                           | 9                 | 12                    | 0             | 0               | 9             | 15                | 0             | 20            | 0             |                          |
| 10                                  | Comply with policy or legislation   | 20  | 25       | 15       | 25       | 25                | 12            | 3             | 3               | 25            | 25              | 5            | 25             | 25                   | 25                     | 25                   | 45                   | 15                      | 5                           | 25                           | 5                           | 12                | 12                    | 0             | 0               | 25            | 15                | 0             | 12            | 25            | 25                       |
| 11                                  | Improve aesthetic quality of site   | -2  | -3       | -2       | -4       | -4                | 2             | -2            | -2              | 2             | 3               | 4            | 9              | 6                    | 6                      | 2                    | 6                    | 2                       | 2                           | 3                            | 3                           | 6                 | 6                     | 5             | 5               | -3            | 0                 | 3             | 9             | 10            | 18                       |
| 12                                  | Improve occupant productivity       | 36  | 25       | -3       | 45       | 45                | 2             | 3             | 3               | 12            | 12              | 15           | 15             | 27                   | 27                     | 12                   | 45                   | 12                      | 12                          | 36                           | 36                          | 9                 | 9                     | 9             | 9               | 20            | 3                 | 0             | 0             | 20            | 20                       |
| 13                                  | Reduce chance of opposition         | 36  | 2        | 2        | 27       | 27                | 2             | -1            | -1              | 5             | 15              | 9            | 9              | 9                    | 9                      | 20                   | 36                   | 9                       | 3                           | 15                           | 20                          | 3                 | 9                     | 6             | 3               | 1             | 0                 | 3             | 0             | 20            | 20                       |
| 14                                  | Increase property value             | 20  | 27       | 18       | 10       | 10                | 1             | 0             | 0               | 15            | 15              | 27           | 45             | 5                    | 5                      | 10                   | 27                   | 6                       | 9                           | 27                           | 27                          | 5                 | 15                    | 6             | 3               | 27            | 5                 | 9             | 9             | 18            |                          |
| 15                                  | Reduce energy consumption           | 20  | 45       | 45       | 25       | 20                | 25            | 45            | 12              | -5            | 10              | 10           | 3              | 2                    | 5                      | 10                   | 9                    | 27                      | 0                           | 20                           | 15                          | 3                 | 3                     | 6             | 6               | 36            | 0                 | 6             | 20            | 4             |                          |
| 16                                  | Provide a secure energy supply      | 27  | 36       | 36       | 27       | 45                | 12            | -5            | -5              | 10            | 10              | 3            | 2              | 5                    | 5                      | 10                   | 9                    | 27                      | 0                           | 20                           | 15                          | 3                 | 3                     | 6             | 6               | 36            | 0                 | 6             | 20            | 4             |                          |
| 17                                  | Facilitate renewable energy         | 12  | 36       | 20       | 6        | 6                 | 3             | -3            | -2              | -2            | 15              | 6            | 9              | 20                   | 20                     | 25                   | 45                   | 10                      | 15                          | 6                            | 6                           | 3                 | 3                     | 2             | 2               | 36            | 2                 | 12            | 12            | 20            | 3                        |
| 18                                  | Lower project capital costs         | 27  | 0        | 0        | 36       | 45                | 4             | 20            | 20              | 20            | 20              | 36           | 45             | 0                    | 36                     | 15                   | 27                   | 27                      | 36                          | 0                            | 36                          | 36                | 12                    | 12            | 0               | 0             | 20                | 25            | 20            | 20            |                          |
| 19                                  | Reduce costs of carbon offset       | 15  | 12       | 3        | 15       | 20                | 1             | -1            | -1              | 10            | 10              | 10           | 10             | 3                    | 6                      | 10                   | 45                   | 6                       | 6                           | 9                            | 12                          | -1                | -1                    | 3             | 3               | 12            | 2                 | 3             | 6             | 5             | 5                        |
| 20                                  | Achieve higher rental rates         | 20  | 27       | 10       | 5        | 5                 | 1             | 0             | 0               | 3             | 15              | 9            | 36             | 3                    | 0                      | 15                   | 18                   | 5                       | 0                           | 18                           | 18                          | 9                 | 27                    | 9             | 3               | 27            | 3                 | 6             | 6             | 15            | 20                       |
| 21                                  | Achieve higher occupancy rates      | 20  | 12       | 27       | 5        | 5                 | 1             | 3             | 2               | 10            | 15              | 27           | 45             | 3                    | 0                      | 15                   | 27                   | 6                       | 0                           | 18                           | 18                          | 5                 | 15                    | 6             | 3               | 6             | 3                 | 6             | 6             | 15            | 20                       |
| 22                                  | Avoid costs due to opposition       | 36  | 6        | 3        | 18       | 36                | 2             | -1            | -1              | 10            | 10              | 9            | 9              | 9                    | 9                      | 20                   | 20                   | 3                       | 3                           | 15                           | 15                          | 10                | 15                    | 3             | 3               | 3             | 0                 | 6             | 6             | 15            | 20                       |
| 23                                  | Gain the public's trust             | 36  | 20       | 20       | 36       | 36                | 0             | 3             | 15              | 3             | 9               | 9            | 15             | 15                   | 15                     | 3                    | 25                   | 12                      | 6                           | 15                           | 15                          | 0                 | 0                     | 9             | 9               | 20            | 0                 | 3             | 3             | 20            | 12                       |
| 24                                  | Decrease outages / interruptions    | 36  | 36       | 25       | 45       | 45                | 4             | 4             | 4               | 3             | 15              | 4            | 3              | 25                   | 25                     | 15                   | 36                   | 5                       | 4                           | 15                           | 15                          | 2                 | 2                     | 3             | 3               | 36            | 0                 | 9             | 12            | 20            | 12                       |
| 25                                  | Attract and retain employees        | 20  | 20       | 20       | 15       | 15                | 1             | 0             | 0               | 15            | 9               | 20           | 20             | 20                   | 20                     | 15                   | 45                   | 12                      | 12                          | 18                           | 27                          | 9                 | 6                     | 6             | 9               | 20            | 9                 | 6             | 2             | 3             | 3                        |
| 26                                  | Improve occupant attendance         | 36  | 45       | 20       | 45       | 45                | 2             | 0             | 0               | 9             | 9               | 12           | 12             | 9                    | 6                      | 15                   | 25                   | 0                       | 0                           | 27                           | 27                          | 6                 | 6                     | 6             | 6               | 27            | 2                 | 3             | 3             | 3             | 3                        |
| 27                                  | Improve occupant health             | 20  | 20       | 20       | 25       | 25                | 12            | 3             | 0               | 2             | 12              | 12           | 15             | 20                   | 2                      | 45                   | 6                    | 9                       | 15                          | 15                           | 3                           | 3                 | 9                     | 9             | 20              | 12            | 3                 | 2             | 9             | 9             |                          |
| 28                                  | Improve corporate reporting results | 15  | 25       | 25       | 20       | 15                | 12            | 0             | 0               | 20            | 10              | 36           | 36             | 12                   | 12                     | 10                   | 36                   | 25                      | 15                          | 27                           | 27                          | 10                | 10                    | 0             | 0               | 25            | 9                 | 20            | 15            | 25            | 25                       |
| 29                                  | Diversify investment portfolios     | 6   | 27       | 18       | 3        | 3                 | 1             | 2             | 1               | 1             | 10              | 15           | 9              | 0                    | 0                      | 10                   | 36                   | 6                       | 6                           | 36                           | 36                          | 6                 | 6                     | 0             | 0               | 27            | 0                 | 3             | 3             | 5             | 15                       |
| 30                                  | Leverage business platforms         | 20  | 45       | 45       | 20       | 5                 | 4             | 1             | 1               | 10            | 10              | 12           | 9              | 0                    | 0                      | 20                   | 36                   | 9                       | 9                           | 36                           | 36                          | 20                | 10                    | 0             | 0               | 45            | 3                 | 3             | 3             | 20            | 15                       |

**Table 45 – Economic Considerations Technical Importance Rating Summary and Data Analysis Calculations, by Stakeholder Group**

| Potential Stakeholder Requirements: |                                     | Economic Impact - Technical Importance |           |          |         |           |          |               |           |          |           |           |          |              |           |          |               |           |          |
|-------------------------------------|-------------------------------------|--|-----------|----------|---------|-----------|----------|---------------|-----------|----------|-----------|-----------|----------|--------------|-----------|----------|---------------|-----------|----------|
|                                     |                                     | Tenant                                 |           |          | Owner   |           |          | Facility Mgr. |           |          | Designers |           |          | Environmntl. |           |          | Weighted Avg. |           |          |
|                                     |                                     | Average                                | Std. Dev. | Variance | Average | Std. Dev. | Variance | Average       | Std. Dev. | Variance | Average   | Std. Dev. | Variance | Average      | Std. Dev. | Variance | Average       | Std. Dev. | Variance |
| 1                                   | Reduce energy costs                 | 30                                     | 11        | 117      | 45      | 0         | 0        | 38.9          | 8.5       | 73       | 22.1      | 10        | 106      | 45           | 0         | 0        | 36.2          | 8.92      | 79.6     |
| 2                                   | Increase return on investment       | 30                                     | 11        | 117      | 45      | 0         | 0        | 42.8          | 3.9       | 15       | 15.3      | 14        | 198      | 20           | 0         | 0        | 30.6          | 11.9      | 140      |
| 3                                   | Minimize environmental impact       | 8.17                                   | 3.5       | 12       | 5.67    | 3.5       | 13       | 9.38          | 7.1       | 50       | 2.71      | 3         | 9.1      | 13.5         | 1.5       | 2.3      | 7.88          | 3.62      | 13.1     |
| 4                                   | Improve your organization's image   | 19.2                                   | 13        | 160      | 9       | 8.5       | 72       | 19.6          | 12        | 148      | 7.29      | 5.7       | 32       | 12           | 3         | 9        | 13.4          | 5.11      | 26.1     |
| 5                                   | Improve occupant comfort            | 8.33                                   | 5.1       | 26       | 6       | 8.8       | 78       | 14            | 5.5       | 30       | 8.29      | 6         | 36       | 9            | 0         | 0        | 9.12          | 2.64      | 6.98     |
| 6                                   | Increase energy efficiency          | 38.7                                   | 7.3       | 54       | 38.3    | 9.4       | 89       | 43.9          | 3         | 8.9      | 18.7      | 13        | 170      | 16           | 4         | 16       | 31.1          | 11.4      | 131      |
| 7                                   | Increase carbon neutrality          | 7.5                                    | 6.1       | 38       | 1       | 2.9       | 8.7      | 6             | 4.1       | 17       | 2         | 2.1       | 4.3      | 3            | 0         | 0        | 3.9           | 2.46      | 6.04     |
| 8                                   | Achieve lower total ownership costs | 25.8                                   | 13        | 164      | 35.2    | 11        | 125      | 34            | 10        | 106      | 26.3      | 19        | 370      | 25           | 0         | 0        | 29.3          | 4.38      | 19.2     |
| 9                                   | Meet regulatory requirements        | 13.3                                   | 8.7       | 77       | 9.83    | 11        | 112      | 15.5          | 13        | 172      | 7.14      | 7.1       | 50       | 0            | 0         | 0        | 9.16          | 5.4       | 29.2     |
| 10                                  | Comply with policy or legislation   | 20.3                                   | 5.2       | 27       | 11      | 9.9       | 99       | 21.3          | 12        | 148      | 8.71      | 8.7       | 75       | 25           | 0         | 0        | 17.3          | 6.28      | 39.5     |
| 11                                  | Improve aesthetic quality of site   | 0                                      | 2         | 4.1      | 1.17    | 2.3       | 5.5      | 4.13          | 2.4       | 5.9      | 4.43      | 3.5       | 12       | 14           | 4         | 16       | 4.74          | 4.93      | 24.3     |
| 12                                  | Improve occupant productivity       | 25                                     | 19        | 372      | 10      | 5.1       | 26       | 25.9          | 12        | 144      | 8         | 6.3       | 39       | 20           | 0         | 0        | 17.8          | 7.47      | 55.8     |
| 13                                  | Reduce chance of opposition         | 16                                     | 14        | 205      | 6       | 5.7       | 33       | 15.1          | 9.6       | 93       | 3.57      | 2.8       | 8        | 20           | 0         | 0        | 12.1          | 6.27      | 39.3     |
| 14                                  | Increase property value             | 14.3                                   | 8.4       | 70       | 17      | 16        | 245      | 14.5          | 9.8       | 97       | 10.6      | 7.6       | 58       | 13.5         | 4.5       | 20       | 14            | 2.07      | 4.27     |
| 15                                  | Reduce energy consumption           | 30                                     | 11        | 117      | 31.7    | 9.4       | 89       | 37.5          | 9.7       | 94       | 16.4      | 14        | 203      | 36           | 0         | 0        | 30.3          | 7.47      | 55.7     |
| 16                                  | Provide a secure energy supply      | 30.5                                   | 10        | 106      | 2.5     | 6.1       | 38       | 11.4          | 8.3       | 69       | 9.43      | 11        | 119      | 12           | 8         | 64       | 13.2          | 9.3       | 86.6     |
| 17                                  | Facilitate renewable energy         | 13.8                                   | 11        | 129      | 3.83    | 6.7       | 45       | 18.4          | 12        | 143      | 10        | 11        | 130      | 11.5         | 8.5       | 72       | 11.5          | 4.77      | 22.7     |
| 18                                  | Lower project capital costs         | 18.7                                   | 18        | 329      | 26.8    | 10        | 100      | 22.1          | 14        | 207      | 20.1      | 12        | 152      | 20           | 0         | 0        | 21.6          | 2.86      | 8.19     |
| 19                                  | Reduce costs of carbon offset       | 11                                     | 6.8       | 46       | 6.33    | 5.2       | 27       | 12.1          | 13        | 161      | 3.57      | 4.1       | 17       | 5            | 0         | 0        | 7.61          | 3.37      | 11.3     |
| 20                                  | Achieve higher rental rates         | 11.3                                   | 9.2       | 85       | 10.5    | 13        | 158      | 9.63          | 7.8       | 61       | 12.4      | 9.4       | 89       | 17.5         | 2.5       | 6.3      | 12.3          | 2.77      | 7.68     |
| 21                                  | Achieve higher occupancy rates      | 11.7                                   | 9.2       | 85       | 17      | 15        | 226      | 10.9          | 9.4       | 88       | 6.71      | 3.5       | 12       | 17.5         | 2.5       | 6.3      | 12.8          | 4.04      | 16.3     |
| 22                                  | Avoid costs due to opposition       | 16.8                                   | 15        | 211      | 6       | 5         | 25       | 11.8          | 6.4       | 41       | 6.57      | 4.2       | 17       | 17.5         | 2.5       | 6.3      | 11.7          | 4.87      | 23.8     |
| 23                                  | Gain the public's trust             | 24.7                                   | 13        | 173      | 7       | 4.5       | 20       | 13.3          | 6.2       | 39       | 6.29      | 6.6       | 43       | 16           | 4         | 16       | 13.4          | 6.71      | 45.1     |
| 24                                  | Decrease outages / interruptions    | 31.8                                   | 14        | 200      | 5.5     | 4.3       | 18       | 17.5          | 10        | 102      | 9.57      | 11        | 129      | 16           | 4         | 16       | 16.1          | 8.99      | 80.9     |
| 25                                  | Attract and retain employees        | 15.2                                   | 6.7       | 45       | 10.7    | 8.4       | 71       | 21.1          | 10        | 103      | 8.29      | 5.3       | 28       | 3            | 0         | 0        | 11.6          | 6.15      | 37.9     |
| 26                                  | Improve occupant attendance         | 32.2                                   | 16        | 261      | 7       | 5.1       | 26       | 13.6          | 11        | 117      | 8.14      | 7.8       | 61       | 3            | 0         | 0        | 12.8          | 10.3      | 105      |
| 27                                  | Improve occupant health             | 20.3                                   | 4.3       | 19       | 5.17    | 4.9       | 24       | 15.9          | 12        | 151      | 7         | 6         | 36       | 9            | 0         | 0        | 11.5          | 5.72      | 32.8     |
| 28                                  | Improve corporate reporting results | 18.7                                   | 5.1       | 26       | 17      | 15        | 226      | 20.5          | 8.9       | 79       | 11.4      | 8.7       | 77       | 25           | 0         | 0        | 18.5          | 4.44      | 19.7     |
| 29                                  | Diversify investment portfolios     | 9.67                                   | 9.6       | 91       | 6.33    | 5.3       | 29       | 16.3          | 16        | 243      | 6.43      | 8.7       | 76       | 10           | 5         | 25       | 9.74          | 3.61      | 13       |
| 30                                  | Leverage business platforms         | 23.2                                   | 17        | 278      | 7.17    | 4.5       | 20       | 18.3          | 15        | 223      | 11.6      | 15        | 229      | 17.5         | 2.5       | 6.3      | 15.5          | 5.57      | 31       |
| S                                   | Minimum                             | 0.0                                    |           |          | 1.0     |           |          | 4.1           |           |          | 2.0       |           |          | 0.0          |           |          | 3.9           |           |          |
| T                                   | 1st Quartile (lower 25%)            | 12.1                                   |           |          | 6.0     |           |          | 12.4          |           |          | 6.6       |           |          | 10.4         |           |          | 11.5          |           |          |
| A                                   | Median                              | 18.7                                   |           |          | 8.1     |           |          | 16.1          |           |          | 8.3       |           |          | 16.0         |           |          | 13.0          |           |          |
| T                                   | 3rd Quartile (upper 25%)            | 25.6                                   |           |          | 17.0    |           |          | 21.2          |           |          | 11.5      |           |          | 20.0         |           |          | 17.6          |           |          |
| S                                   | Maximum                             | 38.7                                   |           |          | 45.0    |           |          | 43.9          |           |          | 26.3      |           |          | 45.0         |           |          | 36.2          |           |          |

## **Appendix J – Individual HOQ’s for Each Stakeholder Group**

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| House of Quality: Tenants               |                                     |                             |  |      |  |      |  |      |   |      |  |      |  |      |  |      |
|---|-------------------------------------|-----------------------------|--|------|--|------|--|------|---|------|--|------|--|------|--|------|
| Potential Stakeholder Requirements:     |                                     | a. Importance (1 - 5 scale) | Technical Considerations (0-1-3-5-9 scale)                       |      |  |      |  |      | Sustainability Considerations (0-1-3-5-9 scale)                       |      |  |      |  |      |  |      |
|   |                                     |                             | b. Mechanical System Retrofits<br>b. Technical Importance (Mech) |      | c. Electrical System Retrofits<br>c. Technical Importance (Elec) |      | d. Plumbing System Retrofits<br>d. Technical Importance (Plumbing) |      | e. Building Enclosure Retrofits<br>e. Technical Importance (Envelope) |      | f. Social Impact<br>f. Technical Importance (Social) |      | g. Environmental Impact<br>g. Technical Importance (Env) |      | h. Economic Impact<br>h. Technical Importance (Economic) |      |
| 1                                       | Increase return on investment (ROI) | 4.9                         | 6.3  | 30.0 | 5.0  | 23.7 | 2.0  | 9.3  | 4.7   | 22.0 | 5.8  | 26.8 | 5.3  | 25.0 | 6.3  | 30.0 |
| 2                                       | Achieve lower total ownership costs | 4.6                         | 6.3  | 30.0 | 4.3  | 20.0 | 2.3  | 10.3 | 2.8   | 12.5 | 0.8  | 4.0  | 0.3  | 1.5  | 6.3  | 30.0 |
| 3                                       | Lower project capital costs         | 3.7                         | 4.7  | 16.8 | 4.0  | 14.5 | 4.7  | 15.8 | 3.7   | 13.2 | 6.8  | 23.5 | 8.3  | 28.8 | 2.3  | 8.2  |
| 4                                       | Reduce energy costs                 | 3.1                         | 2.3  | 7.5  | 1.7  | 5.5  | 1.7  | 5.5  | 3.3   | 11.5 | 4.8  | 16.2 | 5.3  | 16.5 | 5.7  | 19.2 |
| 5                                       | Increase property value             | 3.5                         | 6.7  | 28.0 | 3.0  | 12.0 | 2.0  | 7.3  | 4.0   | 15.7 | 4.2  | 17.5 | 3.0  | 12.3 | 2.0  | 8.3  |
| 6                                       | Achieve higher rental rates         | 4.5                         | 6.3  | 30.0 | 3.7  | 17.0 | 2.0  | 9.3  | 4.0   | 19.0 | 3.5  | 16.5 | 6.3  | 29.3 | 8.3  | 38.7 |
| 7                                       | Achieve higher occupancy rates      | 2.3                         | 3.3  | 10.5 | 3.5  | 10.3 | 0.5  | 1.3  | 2.7   | 7.8  | 4.5  | 13.3 | 7.0  | 19.2 | 2.7  | 7.5  |
| 8                                       | Avoid costs due to opposition       | 4.6                         | 5.7  | 26.2 | 3.3  | 14.5 | 2.3  | 10.2 | 3.7   | 16.2 | 1.2  | 5.2  | 2.0  | 9.2  | 5.7  | 25.8 |
| 9                                       | Improve occupant productivity       | 4.2                         | 3.0  | 10.7 | 3.0  | 10.7 | 3.3  | 11.3 | 2.7   | 9.3  | 3.5  | 13.0 | 4.7  | 17.0 | 3.3  | 13.3 |
| 10                                      | Improve corporate reporting results | 4.6                         | 6.0  | 28.3 | 4.7  | 21.7 | 3.0  | 13.3 | 4.0   | 18.3 | 3.3  | 15.7 | 4.7  | 22.0 | 4.3  | 20.3 |
| 11                                      | Improve your organization's image   | 2.3                         | 0.2  | 0.3  | 0.5  | 1.2  | 0.7  | 1.8  | 6.0   | 16.8 | 4.2  | 12.5 | 5.0  | 14.8 | -0.7   | -2.2 |
| 12                                      | Gain the public's trust             | 3.7                         | 5.3  | 22.7 | 3.0  | 11.3 | 2.0  | 8.0  | 3.2   | 12.2 | 4.2  | 18.3 | 4.0  | 17.3 | 5.3  | 25.0 |
| 13                                      | Reduce chance of opposition         | 2.7                         | 2.2  | 7.0  | 2.2  | 7.0  | 2.7  | 8.0  | 4.7   | 13.3 | 3.3  | 8.7  | 3.0  | 8.0  | 5.0  | 16.0 |
| 14                                      | Improve aesthetic quality of site   | 2.1                         | 3.7  | 8.7  | 3.7  | 8.7  | 3.7  | 8.7  | 5.7   | 13.7 | 0.7  | 1.7  | 2.2  | 5.2  | 5.7  | 14.3 |
| 15                                      | Decrease outages / interruptions    | 4.5                         | 7.0  | 33.3 | 5.0  | 23.7 | 1.8  | 8.5  | 5.3   | 25.3 | 6.8  | 31.8 | 7.0  | 32.7 | 6.3  | 30.0 |
| 16                                      | Attract and retain employees        | 3.4                         | 5.0  | 19.2 | 5.5  | 21.2 | 2.2  | 8.3  | 4.3   | 16.8 | 4.8  | 18.5 | 7.0  | 27.5 | 8.0  | 30.5 |
| 17                                      | Improve occupant attendance         | 3.1                         | 3.0  | 11.5 | 3.5  | 10.8 | 2.5  | 6.8  | 2.8   | 7.8  | 7.0  | 21.8 | 7.0  | 21.8 | 4.0  | 13.8 |
| 18                                      | Improve occupant comfort            | 3.4                         | 2.3  | 10.0 | 2.5  | 10.0 | 2.0  | 8.0  | 1.7   | 7.5  | 0.2  | 0.7  | 0.2  | 0.7  | 7.7  | 18.7 |
| 19                                      | Improve occupant health             | 2.0                         | 3.7  | 12.0 | 3.8  | 12.7 | 0.8  | 2.3  | 3.7   | 12.7 | 3.8  | 13.2 | 8.0  | 26.0 | 3.3  | 11.0 |
| 20                                      | Increase energy efficiency          | 2.2                         | 3.2  | 6.8  | 2.8  | 5.8  | 3.2  | 6.5  | 4.2   | 9.2  | 1.5  | 2.5  | 0.2  | 0.2  | 5.0  | 11.3 |
| 21                                      | Reduce energy consumption           | 2.5                         | 3.7  | 7.7  | 3.3  | 7.3  | 3.3  | 6.7  | 4.0   | 8.7  | 1.5  | 4.0  | 1.7  | 2.7  | 4.7  | 11.7 |
| 22                                      | Provide a secure energy supply      | 2.7                         | 1.7  | 5.5  | 1.7  | 5.5  | 2.7  | 7.8  | 3.3   | 10.8 | 3.7  | 10.2 | 4.0  | 11.5 | 5.3  | 16.8 |
| 23                                      | Facilitate renewable energy         | 3.4                         | 2.0  | 7.3  | 2.0  | 7.3  | 2.0  | 7.3  | 3.3   | 12.7 | 4.3  | 16.7 | 4.0  | 15.3 | 6.3  | 24.7 |
| 24                                      | Minimize environmental impact       | 3.8                         | 7.7  | 35.2 | 6.0  | 27.5 | 5.7  | 26.5 | 1.0   | 4.0  | 4.3  | 19.8 | 1.2  | 5.2  | 7.0  | 31.8 |
| 25                                      | Increase carbon neutrality          | 2.9                         | 2.7  | 9.2  | 2.0  | 7.2  | 2.0  | 7.2  | 3.3   | 12.2 | 4.3  | 15.2 | 2.0  | 7.2  | 4.3  | 15.2 |
| 26                                      | Reduce costs of carbon offset       | 2.7                         | 5.3  | 24.8 | 3.0  | 13.2 | 3.7  | 16.8 | 3.2   | 13.7 | 4.3  | 19.5 | 1.7  | 7.2  | 7.0  | 32.2 |
| 27                                      | Meet regulatory requirements        | 3.3                         | 6.7  | 29.7 | 2.7  | 11.0 | 3.7  | 16.3 | 3.7   | 16.0 | 6.3  | 28.3 | 2.0  | 8.3  | 4.7  | 20.3 |
| 28                                      | Comply with policy or legislation   | 3.8                         | 5.0  | 21.3 | 6.0  | 24.3 | 4.3  | 17.3 | 5.0   | 21.3 | 6.7  | 26.7 | 3.7  | 16.0 | 4.7  | 18.7 |
| 29                                      | Diversify investment portfolios     | 1.9                         | 3.5  | 6.2  | 2.8  | 4.5  | 2.8  | 4.5  | 2.5   | 3.8  | 0.7  | 1.3  | 0.8  | 1.3  | 4.7  | 9.7  |
| 30                                      | Leverage business platforms         | 3.1                         | 5.3  | 19.2 | 4.3  | 17.2 | 2.3  | 8.8  | 4.0   | 12.5 | 2.8  | 9.8  | 0.8  | 3.0  | 5.7  | 23.2 |
| Σ Technical Importance                  |                                     |                             | 516  |      | 387  |      | 280  |      | 397   |      | 433  |      | 413  |      | 574  |      |
| Relative Weight (1-5, 5 most important) |                                     |                             | 5.0  |      | 3.8  |      | 2.7  |      | 3.8   |      | 3.8  |      | 3.6  |      | 5.0  |      |

Figure 33 – Tenant HOQ

| House of Quality: Owners                |                                     |                             |  |      |  |      |  |      |   |      |  |      |  |      |  |      |
|---|-------------------------------------|-----------------------------|--|------|--|------|--|------|---|------|--|------|--|------|--|------|
| Potential Stakeholder Requirements:     |                                     | a. Importance (1 - 5 scale) | Technical Considerations (0-1-3-5-9 scale)                       |      |  |      |  |      |   |      | Sustainability Considerations (0-1-3-5-9 scale)      |      |  |      |  |      |
|   |                                     |                             | b. Mechanical System Retrofits<br>b. Technical Importance (Mech) |      | c. Electrical System Retrofits<br>c. Technical Importance (Elec) |      | d. Plumbing System Retrofits<br>d. Technical Importance (Plumbing) |      | e. Building Enclosure Retrofits<br>e. Technical Importance (Envelope) |      | f. Social Impact<br>f. Technical Importance (Social) |      | g. Environmental Impact<br>g. Technical Importance (Env) |      | h. Economic Impact<br>h. Technical Importance (Economic) |      |
| 1                                       | Increase return on investment (ROI) | 4.9                         | 5.7  | 28.3 | 5.0  | 25.0 | 3.0  | 15.0 | 2.3   | 11.7 | 4.0  | 20.0 | 2.0  | 10.0 | 9.0  | 45.0 |
| 2                                       | Achieve lower total ownership costs | 4.6                         | 5.0  | 25.0 | 5.0  | 25.0 | 3.0  | 15.0 | 1.7   | 8.3  | 2.0  | 10.0 | 0.3  | 1.7  | 9.0  | 45.0 |
| 3                                       | Lower project capital costs         | 3.7                         | 3.7  | 12.3 | 2.3  | 7.7  | 3.7  | 12.3 | 1.7   | 5.3  | 5.0  | 16.7 | 6.3  | 20.7 | 1.7  | 5.7  |
| 4                                       | Reduce energy costs                 | 3.1                         | 1.0  | 3.7  | 1.7  | 7.0  | 1.0  | 3.7  | 4.3   | 19.0 | 4.3  | 16.3 | 3.3  | 13.3 | 2.3  | 9.0  |
| 5                                       | Increase property value             | 3.5                         | 7.7  | 29.0 | 3.0  | 11.7 | 1.3  | 5.0  | 6.3   | 23.7 | 3.7  | 13.7 | 1.0  | 3.7  | 1.7  | 6.0  |
| 6                                       | Achieve higher rental rates         | 4.5                         | 5.7  | 28.3 | 6.3  | 31.7 | 1.3  | 6.7  | 3.7   | 18.3 | 3.0  | 15.0 | 3.7  | 18.3 | 7.7  | 38.3 |
| 7                                       | Achieve higher occupancy rates      | 2.3                         | 5.7  | 12.7 | 6.3  | 14.0 | 1.3  | 3.0  | 3.0   | 7.0  | 2.3  | 5.0  | 5.7  | 10.0 | 1.3  | 1.0  |
| 8                                       | Avoid costs due to opposition       | 4.6                         | 6.3  | 29.2 | 5.0  | 22.5 | 3.3  | 15.5 | 4.3   | 20.8 | 1.7  | 7.2  | 1.0  | 4.5  | 7.7  | 35.2 |
| 9                                       | Improve occupant productivity       | 4.2                         | 3.3  | 14.2 | 3.3  | 14.2 | 3.0  | 13.5 | 2.0   | 9.2  | 3.0  | 12.5 | 3.7  | 16.8 | 2.3  | 9.8  |
| 10                                      | Improve corporate reporting results | 4.6                         | 5.0  | 21.7 | 6.3  | 25.7 | 5.7  | 22.3 | 3.0   | 13.0 | 3.0  | 11.7 | 3.0  | 13.0 | 2.3  | 11.0 |
| 11                                      | Improve your organization's image   | 2.3                         | 0.3  | 0.7  | 1.3  | 2.7  | 0.5  | 1.2  | 6.0   | 16.5 | 3.7  | 9.8  | 0.3  | 0.7  | 0.3  | 1.2  |
| 12                                      | Gain the public's trust             | 3.7                         | 5.0  | 16.0 | 3.0  | 10.0 | 1.3  | 4.3  | 3.0   | 9.3  | 3.7  | 12.0 | 1.3  | 4.3  | 3.0  | 10.0 |
| 13                                      | Reduce chance of opposition         | 2.7                         | 1.3  | 3.0  | 1.7  | 3.3  | 1.0  | 2.7  | 2.7   | 6.3  | 3.7  | 8.0  | 2.0  | 5.0  | 2.3  | 6.0  |
| 14                                      | Improve aesthetic quality of site   | 2.1                         | 2.7  | 7.7  | 2.0  | 6.7  | 2.0  | 6.7  | 5.0   | 15.0 | 1.0  | 2.3  | 0.7  | 1.8  | 5.0  | 17.0 |
| 15                                      | Decrease outages / interruptions    | 4.5                         | 6.3  | 31.7 | 5.7  | 28.3 | 3.3  | 16.7 | 3.7   | 18.3 | 3.0  | 15.0 | 3.0  | 15.0 | 6.3  | 31.7 |
| 16                                      | Attract and retain employees        | 3.4                         | 2.3  | 6.5  | 1.0  | 3.2  | 1.0  | 3.2  | 1.0   | 3.2  | 4.3  | 13.2 | 1.3  | 3.7  | 1.7  | 2.5  |
| 17                                      | Improve occupant attendance         | 3.1                         | 3.7  | 9.8  | 2.3  | 5.8  | 1.7  | 3.8  | 2.7   | 6.5  | 4.3  | 10.8 | 5.0  | 12.5 | 1.3  | 3.8  |
| 18                                      | Improve occupant comfort            | 3.4                         | 7.0  | 29.5 | 4.0  | 16.8 | 1.8  | 7.8  | 4.8   | 20.8 | 2.7  | 11.2 | 2.7  | 11.2 | 6.3  | 26.8 |
| 19                                      | Improve occupant health             | 2.0                         | 2.7  | 5.3  | 4.0  | 8.0  | 0.8  | 1.5  | 2.0   | 3.8  | 3.7  | 6.3  | 3.0  | 4.3  | 3.0  | 6.3  |
| 20                                      | Increase energy efficiency          | 2.2                         | 1.8  | 4.0  | 1.8  | 5.0  | 0.8  | 3.0  | 3.0   | 6.2  | 2.0  | 4.7  | 0.7  | 1.8  | 5.0  | 10.5 |
| 21                                      | Reduce energy consumption           | 2.5                         | 4.3  | 12.3 | 2.0  | 6.0  | 1.3  | 4.7  | 3.7   | 11.0 | 2.0  | 7.7  | 1.0  | 3.0  | 5.0  | 17.0 |
| 22                                      | Provide a secure energy supply      | 2.7                         | 0.7  | 1.7  | 1.0  | 2.0  | 1.7  | 4.0  | 2.0   | 5.0  | 3.7  | 8.0  | 2.3  | 5.0  | 2.3  | 6.0  |
| 23                                      | Facilitate renewable energy         | 3.4                         | 0.3  | 1.0  | 0.3  | 1.0  | 0.8  | 2.5  | 1.7   | 5.0  | 4.3  | 13.0 | 3.7  | 11.0 | 2.3  | 7.0  |
| 24                                      | Minimize environmental impact       | 3.8                         | 5.0  | 17.5 | 4.7  | 15.8 | 2.3  | 8.2  | 1.7   | 5.8  | 1.3  | 4.2  | 0.3  | 1.2  | 1.7  | 5.5  |
| 25                                      | Increase carbon neutrality          | 2.9                         | 3.0  | 12.0 | 1.7  | 6.7  | 1.7  | 7.3  | 3.7   | 15.3 | 2.3  | 10.0 | 2.0  | 7.0  | 2.7  | 10.7 |
| 26                                      | Reduce costs of carbon offset       | 2.7                         | 3.0  | 8.0  | 2.3  | 6.3  | 1.0  | 3.0  | 3.0   | 9.0  | 3.0  | 9.0  | 0.7  | 1.7  | 2.0  | 7.0  |
| 27                                      | Meet regulatory requirements        | 3.3                         | 5.0  | 15.0 | 2.3  | 7.7  | 2.3  | 7.3  | 2.3   | 7.3  | 3.7  | 11.7 | 0.7  | 2.0  | 1.5  | 5.2  |
| 28                                      | Comply with policy or legislation   | 3.8                         | 2.3  | 7.8  | 1.7  | 5.8  | 1.3  | 4.5  | 1.7   | 5.8  | 2.3  | 6.5  | 1.7  | 4.8  | 4.7  | 17.0 |
| 29                                      | Diversify investment portfolios     | 1.9                         | 0.3  | 0.7  | 0.7  | 1.0  | 0.0  | 0.0  | 1.3   | 3.5  | 1.7  | 4.0  | 0.3  | 0.5  | 2.7  | 6.3  |
| 30                                      | Leverage business platforms         | 3.1                         | 0.8  | 1.5  | 0.5  | 1.2  | 0.5  | 0.8  | 1.0   | 2.8  | 1.3  | 4.2  | 0.7  | 1.8  | 3.0  | 7.2  |
| Σ Technical Importance                  |                                     |                             | 396  |      | 328  |      | 205  |      | 313   |      | 300  |      | 210  |      | 411  |      |
| Relative Weight (1-5, 5 most important) |                                     |                             | 5.0  |      | 4.1  |      | 2.6  |      | 4.0   |      | 3.6  |      | 2.6  |      | 5.0  |      |

Figure 34 – Owner HOQ

| House of Quality: Facility Managers     |                                     |                             |  |      |  |      |  |      |   |      |  |      |  |      |  |      |
|---|-------------------------------------|-----------------------------|--|------|--|------|--|------|---|------|--|------|--|------|--|------|
| Potential Stakeholder Requirements:     |                                     | a. Importance (1 - 5 scale) | Technical Considerations (0-1-3-5-9 scale)                       |      |  |      |  |      |   |      | Sustainability Considerations (0-1-3-5-9 scale)      |      |  |      |  |      |
|   |                                     |                             | b. Mechanical System Retrofits<br>b. Technical Importance (Mech) |      | c. Electrical System Retrofits<br>c. Technical Importance (Elec) |      | d. Plumbing System Retrofits<br>d. Technical Importance (Plumbing) |      | e. Building Enclosure Retrofits<br>e. Technical Importance (Envelope) |      | f. Social Impact<br>f. Technical Importance (Social) |      | g. Environmental Impact<br>g. Technical Importance (Env) |      | h. Economic Impact<br>h. Technical Importance (Economic) |      |
| 1                                       | Increase return on investment (ROI) | 4.9                         | 5.5  | 26.9 | 6.3  | 30.1 | 2.8  | 13.4 | 5.8   | 28.4 | 4.8  | 23.6 | 4.5  | 21.9 | 8.0  | 38.9 |
| 2                                       | Achieve lower total ownership costs | 4.6                         | 4.8  | 22.5 | 5.8  | 27.5 | 3.3  | 15.5 | 4.8   | 23.0 | 4.9  | 23.1 | 2.1  | 9.4  | 9.0  | 42.8 |
| 3                                       | Lower project capital costs         | 3.7                         | 4.8  | 18.6 | 4.0  | 15.9 | 5.3  | 20.9 | 5.5   | 21.9 | 8.0  | 31.4 | 8.5  | 33.4 | 2.3  | 9.4  |
| 4                                       | Reduce energy costs                 | 3.1                         | 1.5  | 5.1  | 4.3  | 14.4 | 2.5  | 7.6  | 7.3   | 22.9 | 6.5  | 20.6 | 3.8  | 13.5 | 6.0  | 19.6 |
| 5                                       | Increase property value             | 3.5                         | 7.5  | 27.8 | 3.3  | 12.3 | 1.9  | 6.8  | 4.0   | 15.3 | 5.5  | 20.8 | 2.0  | 7.8  | 3.8  | 14.0 |
| 6                                       | Achieve higher rental rates         | 4.5                         | 8.5  | 41.4 | 7.5  | 36.4 | 4.8  | 22.6 | 7.0   | 34.4 | 5.5  | 27.1 | 5.8  | 27.6 | 9.0  | 43.9 |
| 7                                       | Achieve higher occupancy rates      | 2.3                         | 4.8  | 12.8 | 5.5  | 13.3 | 1.9  | 5.3  | 4.5   | 11.5 | 8.0  | 19.5 | 7.8  | 18.8 | 2.5  | 6.0  |
| 8                                       | Avoid costs due to opposition       | 4.6                         | 6.5  | 29.5 | 6.5  | 29.5 | 4.3  | 19.3 | 5.8   | 26.5 | 3.5  | 16.0 | 2.8  | 12.9 | 7.5  | 34.0 |
| 9                                       | Improve occupant productivity       | 4.2                         | 5.0  | 23.3 | 5.5  | 25.3 | 6.8  | 31.3 | 4.3   | 20.0 | 5.5  | 24.0 | 6.3  | 27.3 | 3.3  | 15.5 |
| 10                                      | Improve corporate reporting results | 4.6                         | 5.0  | 25.0 | 5.5  | 27.5 | 5.5  | 27.5 | 4.5   | 22.5 | 6.0  | 30.0 | 5.8  | 28.8 | 4.3  | 21.3 |
| 11                                      | Improve your organization's image   | 2.3                         | 0.8  | 1.6  | 3.5  | 7.4  | 1.5  | 3.6  | 8.0   | 19.4 | 7.3  | 17.9 | 1.9  | 4.4  | 1.8  | 4.1  |
| 12                                      | Gain the public's trust             | 3.7                         | 5.5  | 21.6 | 4.8  | 18.4 | 3.3  | 12.4 | 3.8   | 14.4 | 6.8  | 26.9 | 2.0  | 7.6  | 6.8  | 25.9 |
| 13                                      | Reduce chance of opposition         | 2.7                         | 2.5  | 8.6  | 2.3  | 8.1  | 2.3  | 7.6  | 3.8   | 12.9 | 7.0  | 24.4 | 4.1  | 13.9 | 4.3  | 15.1 |
| 14                                      | Improve aesthetic quality of site   | 2.1                         | 3.5  | 8.3  | 3.8  | 9.3  | 3.3  | 8.0  | 5.5   | 12.5 | 2.3  | 3.8  | 1.5  | 2.5  | 6.0  | 14.5 |
| 15                                      | Decrease outages / interruptions    | 4.5                         | 8.0  | 40.0 | 7.5  | 37.5 | 3.3  | 16.3 | 5.8   | 28.8 | 5.0  | 25.0 | 5.9  | 29.4 | 7.5  | 37.5 |
| 16                                      | Attract and retain employees        | 3.4                         | 2.3  | 6.9  | 5.3  | 20.6 | 1.5  | 4.6  | 1.0   | 2.9  | 3.6  | 11.6 | 3.1  | 10.4 | 3.6  | 11.4 |
| 17                                      | Improve occupant attendance         | 3.1                         | 3.5  | 8.9  | 7.0  | 23.9 | 2.3  | 5.9  | 5.0   | 13.9 | 5.8  | 21.1 | 6.3  | 20.6 | 5.0  | 18.4 |
| 18                                      | Improve occupant comfort            | 3.4                         | 2.5  | 7.8  | 2.1  | 6.9  | 1.8  | 4.5  | 1.8   | 6.5  | 3.0  | 8.3  | 2.5  | 7.1  | 8.5  | 22.1 |
| 19                                      | Improve occupant health             | 2.0                         | 5.0  | 14.9 | 5.5  | 16.9 | 2.3  | 7.4  | 4.8   | 11.4 | 6.0  | 18.4 | 5.8  | 17.6 | 4.0  | 12.1 |
| 20                                      | Increase energy efficiency          | 2.2                         | 2.4  | 3.6  | 1.8  | 2.9  | 1.3  | 1.6  | 2.9   | 4.9  | 2.3  | 3.0  | 1.8  | 2.3  | 5.4  | 9.6  |
| 21                                      | Reduce energy consumption           | 2.5                         | 3.8  | 5.6  | 2.0  | 3.6  | 1.8  | 2.9  | 2.3   | 5.3  | 3.3  | 8.4  | 1.3  | 2.9  | 5.1  | 10.9 |
| 22                                      | Provide a secure energy supply      | 2.7                         | 1.5  | 5.0  | 1.8  | 6.0  | 1.8  | 6.0  | 2.8   | 9.5  | 5.0  | 15.8 | 3.0  | 9.8  | 3.5  | 11.8 |
| 23                                      | Facilitate renewable energy         | 3.4                         | 1.5  | 5.3  | 1.8  | 6.5  | 1.5  | 5.3  | 2.5   | 8.8  | 5.0  | 18.3 | 2.8  | 11.5 | 3.5  | 13.3 |
| 24                                      | Minimize environmental impact       | 3.8                         | 4.8  | 18.0 | 5.8  | 23.0 | 3.0  | 14.0 | 1.8   | 8.3  | 3.8  | 14.4 | 1.0  | 3.9  | 4.5  | 17.5 |
| 25                                      | Increase carbon neutrality          | 2.9                         | 2.8  | 9.9  | 3.8  | 13.4 | 2.6  | 9.4  | 5.0   | 19.6 | 4.0  | 15.4 | 3.0  | 12.9 | 5.8  | 21.1 |
| 26                                      | Reduce costs of carbon offset       | 2.7                         | 4.5  | 14.1 | 3.0  | 9.9  | 2.1  | 7.3  | 3.3   | 11.6 | 3.3  | 11.9 | 2.0  | 8.1  | 4.0  | 13.6 |
| 27                                      | Meet regulatory requirements        | 3.3                         | 6.5  | 20.9 | 2.5  | 7.9  | 1.9  | 6.5  | 2.3   | 7.5  | 5.5  | 17.4 | 3.3  | 10.6 | 4.5  | 15.9 |
| 28                                      | Comply with policy or legislation   | 3.8                         | 1.8  | 5.5  | 3.5  | 12.5 | 3.5  | 12.0 | 3.5   | 12.5 | 5.5  | 19.0 | 3.5  | 12.5 | 6.0  | 20.5 |
| 29                                      | Diversify investment portfolios     | 1.9                         | 1.5  | 5.3  | 1.5  | 5.3  | 1.8  | 5.8  | 1.8   | 5.8  | 1.8  | 4.8  | 3.0  | 8.3  | 4.8  | 16.3 |
| 30                                      | Leverage business platforms         | 3.1                         | 1.8  | 6.3  | 2.3  | 7.4  | 1.3  | 4.8  | 2.3   | 7.8  | 2.3  | 7.8  | 2.0  | 6.8  | 4.8  | 18.3 |
| Σ Technical Importance                  |                                     |                             | 451  |      | 479  |      | 316  |      | 450   |      | 529  |      | 404  |      | 575  |      |
| Relative Weight (1-5, 5 most important) |                                     |                             | 4.7  |      | 5.0  |      | 3.3  |      | 4.7   |      | 4.6  |      | 3.5  |      | 5.0  |      |

Figure 35 – Facility Manager HOQ

| House of Quality: Designers             |                                     |                             |  |      |  |      |  |      |   |      |  |      |  |      |  |      |
|---|-------------------------------------|-----------------------------|--|------|--|------|--|------|---|------|--|------|--|------|--|------|
| Potential Stakeholder Requirements:     |                                     | a. Importance (1 - 5 scale) | Technical Considerations (0-1-3-5-9 scale)                       |      |  |      |  |      | Sustainability Considerations (0-1-3-5-9 scale)                       |      |  |      |  |      |  |      |
|   |                                     |                             | b. Mechanical System Retrofits<br>b. Technical Importance (Mech) |      | c. Electrical System Retrofits<br>c. Technical Importance (Elec) |      | d. Plumbing System Retrofits<br>d. Technical Importance (Plumbing) |      | e. Building Enclosure Retrofits<br>e. Technical Importance (Envelope) |      | f. Social Impact<br>f. Technical Importance (Social) |      | g. Environmental Impact<br>g. Technical Importance (Env) |      | h. Economic Impact<br>h. Technical Importance (Economic) |      |
| 1                                       | Increase return on investment (ROI) | 4.9                         | 8.4  | 42.1 | 4.1  | 23.6 | 1.9  | 9.3  | 6.3   | 33.6 | 3.3  | 16.4 | 2.7  | 13.6 | 4.4  | 22.1 |
| 2                                       | Achieve lower total ownership costs | 4.6                         | 6.1  | 29.3 | 3.8  | 19.6 | 1.3  | 6.1  | 4.8   | 25.0 | 0.1  | 0.7  | 0.3  | 1.3  | 3.3  | 15.3 |
| 3                                       | Lower project capital costs         | 3.7                         | 4.4  | 15.9 | 2.5  | 9.6  | 1.6  | 5.6  | 3.8   | 14.1 | 5.0  | 16.7 | 5.0  | 16.7 | 0.9  | 2.7  |
| 4                                       | Reduce energy costs                 | 3.1                         | 1.9  | 4.7  | 2.3  | 6.1  | 1.9  | 5.0  | 3.3   | 8.1  | 2.7  | 7.3  | 3.3  | 7.3  | 2.7  | 7.3  |
| 5                                       | Increase property value             | 3.5                         | 8.1  | 24.9 | 3.5  | 11.1 | 1.6  | 5.9  | 5.0   | 15.1 | 2.4  | 9.3  | 0.9  | 3.4  | 2.4  | 8.3  |
| 6                                       | Achieve higher rental rates         | 4.5                         | 8.4  | 31.9 | 5.5  | 21.0 | 2.1  | 8.1  | 7.5   | 30.4 | 2.7  | 11.1 | 2.4  | 9.6  | 4.4  | 18.7 |
| 7                                       | Achieve higher occupancy rates      | 2.3                         | 3.3  | 5.3  | 1.9  | 2.6  | 0.6  | 0.3  | 2.5   | 4.1  | 2.7  | 4.1  | 3.9  | 6.4  | 1.6  | 2.0  |
| 8                                       | Avoid costs due to opposition       | 4.6                         | 6.1  | 29.1 | 3.0  | 14.3 | 1.9  | 8.9  | 4.8   | 24.9 | 0.3  | 1.4  | 1.3  | 5.6  | 5.6  | 26.3 |
| 9                                       | Improve occupant productivity       | 4.2                         | 1.6  | 5.6  | 1.9  | 5.9  | 1.6  | 5.6  | 2.1   | 7.9  | 3.9  | 13.9 | 4.1  | 14.7 | 2.0  | 7.1  |
| 10                                      | Improve corporate reporting results | 4.6                         | 3.9  | 15.9 | 3.8  | 16.4 | 1.3  | 5.3  | 2.8   | 12.1 | 3.0  | 11.9 | 4.1  | 16.4 | 2.0  | 8.7  |
| 11                                      | Improve your organization's image   | 2.3                         | 1.1  | 2.3  | 2.0  | 3.9  | 1.0  | 2.4  | 5.5   | 11.6 | 3.9  | 7.6  | 2.4  | 5.7  | 3.0  | 4.4  |
| 12                                      | Gain the public's trust             | 3.7                         | 2.7  | 8.9  | 2.0  | 7.1  | 0.7  | 2.6  | 2.5   | 8.9  | 1.4  | 5.0  | 1.0  | 3.7  | 2.4  | 8.0  |
| 13                                      | Reduce chance of opposition         | 2.7                         | 0.4  | 0.9  | 0.4  | 0.9  | 0.7  | 1.1  | 1.8   | 3.3  | 5.0  | 8.4  | 3.3  | 5.0  | 2.3  | 3.6  |
| 14                                      | Improve aesthetic quality of site   | 2.1                         | 2.4  | 6.3  | 1.5  | 4.0  | 1.0  | 2.9  | 5.0   | 12.9 | 0.9  | 1.7  | 0.3  | 0.7  | 4.4  | 10.6 |
| 15                                      | Decrease outages / interruptions    | 4.5                         | 9.0  | 34.7 | 4.5  | 20.1 | 2.0  | 7.4  | 4.5   | 19.3 | 3.9  | 16.1 | 3.9  | 15.9 | 3.9  | 16.4 |
| 16                                      | Attract and retain employees        | 3.4                         | 2.3  | 7.4  | 2.3  | 6.0  | 0.4  | 1.4  | 2.1   | 7.0  | 1.6  | 5.4  | 1.6  | 6.0  | 3.3  | 9.4  |
| 17                                      | Improve occupant attendance         | 3.1                         | 2.4  | 8.3  | 2.8  | 8.9  | 1.1  | 2.9  | 1.5   | 5.6  | 3.9  | 12.9 | 5.6  | 18.0 | 2.7  | 10.0 |
| 18                                      | Improve occupant comfort            | 3.4                         | 4.3  | 18.4 | 3.4  | 16.1 | 2.7  | 11.0 | 4.8   | 23.0 | 0.3  | 1.1  | 0.3  | 1.1  | 6.1  | 20.1 |
| 19                                      | Improve occupant health             | 2.0                         | 2.4  | 5.0  | 1.5  | 2.1  | 1.1  | 1.3  | 2.0   | 3.9  | 3.9  | 6.4  | 5.6  | 9.9  | 1.9  | 3.6  |
| 20                                      | Increase energy efficiency          | 2.2                         | 1.6  | 4.4  | 1.0  | 3.3  | 1.3  | 2.7  | 3.6   | 9.0  | 0.9  | 1.7  | 0.3  | 0.6  | 5.6  | 12.4 |
| 21                                      | Reduce energy consumption           | 2.5                         | 1.9  | 3.6  | 1.8  | 4.7  | 1.6  | 3.6  | 3.4   | 8.7  | 0.9  | 2.1  | 0.0  | 0.0  | 3.6  | 6.7  |
| 22                                      | Provide a secure energy supply      | 2.7                         | 1.1  | 2.6  | 0.6  | 1.3  | 1.0  | 1.3  | 1.6   | 3.1  | 3.6  | 6.0  | 3.3  | 5.4  | 3.6  | 6.6  |
| 23                                      | Facilitate renewable energy         | 3.4                         | 1.6  | 4.3  | 1.0  | 3.1  | 0.7  | 2.6  | 1.9   | 6.3  | 3.9  | 11.1 | 3.9  | 11.1 | 1.9  | 6.3  |
| 24                                      | Minimize environmental impact       | 3.8                         | 3.3  | 9.9  | 2.9  | 10.4 | 0.4  | 1.1  | 1.0   | 2.7  | 1.0  | 3.6  | 0.0  | 0.0  | 2.7  | 9.6  |
| 25                                      | Increase carbon neutrality          | 2.9                         | 2.4  | 6.0  | 2.3  | 6.0  | 1.6  | 4.0  | 3.5   | 10.3 | 1.9  | 5.1  | 1.1  | 3.7  | 3.0  | 8.3  |
| 26                                      | Reduce costs of carbon offset       | 2.7                         | 2.1  | 5.9  | 1.1  | 3.1  | 1.3  | 3.6  | 1.3   | 3.3  | 1.7  | 4.3  | 0.4  | 1.3  | 3.3  | 8.1  |
| 27                                      | Meet regulatory requirements        | 3.3                         | 3.9  | 11.6 | 1.1  | 4.1  | 2.1  | 6.1  | 2.3   | 7.6  | 1.7  | 6.0  | 0.7  | 2.9  | 2.1  | 7.0  |
| 28                                      | Comply with policy or legislation   | 3.8                         | 3.0  | 11.0 | 2.5  | 11.0 | 1.9  | 6.7  | 3.5   | 14.4 | 2.7  | 11.4 | 2.7  | 11.4 | 3.6  | 11.4 |
| 29                                      | Diversify investment portfolios     | 1.9                         | 1.9  | 4.1  | 1.4  | 2.9  | 1.0  | 2.0  | 1.3   | 3.1  | 0.3  | 0.3  | 0.3  | 0.6  | 3.0  | 6.4  |
| 30                                      | Leverage business platforms         | 3.1                         | 1.9  | 7.6  | 1.6  | 7.6  | 1.0  | 3.3  | 0.9   | 3.3  | 1.6  | 4.4  | 0.4  | 0.4  | 3.6  | 11.6 |
| Σ Technical Importance                  |                                     |                             | 368  |      | 257  |      | 130  |      | 343   |      | 214  |      | 198  |      | 299  |      |
| Relative Weight (1-5, 5 most important) |                                     |                             | 5.0  |      | 3.5  |      | 1.8  |      | 4.7   |      | 3.6  |      | 3.3  |      | 5.0  |      |

Figure 36 – Designer HOQ

| House of Quality: Environmental Compliance Managers |                                     |                             |  |      |  |      |  |      |   |      |  |      |  |      |  |      |
|---|-------------------------------------|-----------------------------|--|------|--|------|--|------|---|------|--|------|--|------|--|------|
| Potential Stakeholder Requirements:                 |                                     | a. Importance (1 - 5 scale) | Technical Considerations (0-1-3-5-9 scale)                       |      |  |      |  |      | Sustainability Considerations (0-1-3-5-9 scale)                       |      |  |      |  |      |  |      |
|   |                                     |                             | b. Mechanical System Retrofits<br>b. Technical Importance (Mech) |      | c. Electrical System Retrofits<br>c. Technical Importance (Elec) |      | d. Plumbing System Retrofits<br>d. Technical Importance (Plumbing) |      | e. Building Enclosure Retrofits<br>e. Technical Importance (Envelope) |      | f. Social Impact<br>f. Technical Importance (Social) |      | g. Environmental Impact<br>g. Technical Importance (Env) |      | h. Economic Impact<br>h. Technical Importance (Economic) |      |
| 1   | Increase return on investment (ROI) | 4.9                         | 5.0  | 25.0 | 2.0  | 10.0 | 1.0  | 5.0  | 5.0   | 25.0 | 2.0  | 10.0 | 5.0  | 25.0 | 9.0  | 45.0 |
| 2   | Achieve lower total ownership costs | 4.6                         | 5.0  | 20.0 | 2.0  | 8.0  | 1.0  | 4.0  | 5.0   | 20.0 | 2.0  | 8.0  | 3.0  | 12.0 | 5.0  | 20.0 |
| 3   | Lower project capital costs         | 3.7                         | 5.0  | 22.5 | 4.0  | 18.5 | 3.0  | 13.5 | 1.0   | 4.5  | 5.0  | 22.5 | 5.0  | 22.5 | 3.0  | 13.5 |
| 4   | Reduce energy costs                 | 3.1                         | 1.0  | 3.0  | 5.0  | 15.0 | 1.0  | 3.0  | 4.0   | 12.0 | 5.0  | 15.0 | 4.0  | 12.0 | 4.0  | 12.0 |
| 5   | Increase property value             | 3.5                         | 5.0  | 15.0 | 2.0  | 6.0  | 1.0  | 3.0  | 5.0   | 15.0 | 2.0  | 6.0  | 2.0  | 6.0  | 3.0  | 9.0  |
| 6   | Achieve higher rental rates         | 4.5                         | 5.0  | 20.0 | 4.0  | 16.0 | 1.0  | 4.0  | 5.0   | 20.0 | 3.0  | 12.0 | 4.0  | 16.0 | 4.0  | 16.0 |
| 7   | Achieve higher occupancy rates      | 2.3                         | 5.0  | 15.0 | 5.0  | 15.0 | 0.0  | 0.0  | 5.0   | 15.0 | 5.0  | 15.0 | 5.0  | 15.0 | 1.0  | 3.0  |
| 8   | Avoid costs due to opposition       | 4.6                         | 5.0  | 25.0 | 5.0  | 25.0 | 4.0  | 20.0 | 5.0   | 25.0 | 1.0  | 5.0  | 1.0  | 5.0  | 5.0  | 25.0 |
| 9   | Improve occupant productivity       | 4.2                         | 5.0  | 25.0 | 1.0  | 5.0  | 5.0  | 25.0 | 4.0   | 20.0 | 1.0  | 5.0  | 9.0  | 45.0 | 0.0  | 0.0  |
| 10  | Improve corporate reporting results | 4.6                         | 5.0  | 25.0 | 5.0  | 25.0 | 5.0  | 25.0 | 4.0   | 20.0 | 1.5  | 7.5  | 5.0  | 25.0 | 5.0  | 25.0 |
| 11  | Improve your organization's image   | 2.3                         | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 5.0   | 10.0 | 2.0  | 4.0  | 2.0  | 4.0  | 7.0  | 14.0 |
| 12  | Gain the public's trust             | 3.7                         | 1.0  | 4.0  | 1.0  | 4.0  | 1.0  | 4.0  | 1.0   | 4.0  | 0.5  | 2.0  | 1.0  | 4.0  | 5.0  | 20.0 |
| 13  | Reduce chance of opposition         | 2.7                         | 3.0  | 12.0 | 5.0  | 20.0 | 3.0  | 12.0 | 5.0   | 20.0 | 5.0  | 20.0 | 5.0  | 20.0 | 5.0  | 20.0 |
| 14  | Improve aesthetic quality of site   | 2.1                         | 3.0  | 4.5  | 1.0  | 1.5  | 1.0  | 1.5  | 3.0   | 4.5  | 0.0  | 0.0  | 1.5  | 1.5  | 9.0  | 13.5 |
| 15  | Decrease outages / interruptions    | 4.5                         | 5.0  | 20.0 | 5.0  | 20.0 | 1.0  | 4.0  | 5.0   | 20.0 | 6.0  | 24.0 | 4.0  | 16.0 | 9.0  | 36.0 |
| 16  | Attract and retain employees        | 3.4                         | 4.0  | 16.0 | 5.0  | 20.0 | 1.0  | 4.0  | 1.0   | 4.0  | 3.0  | 12.0 | 5.0  | 20.0 | 3.0  | 12.0 |
| 17  | Improve occupant attendance         | 3.1                         | 5.0  | 17.5 | 5.0  | 17.5 | 1.0  | 3.5  | 4.0   | 14.5 | 4.0  | 14.5 | 4.0  | 14.5 | 3.0  | 11.5 |
| 18  | Improve occupant comfort            | 3.4                         | 3.0  | 12.0 | 3.0  | 12.0 | 3.0  | 12.0 | 3.0   | 12.0 | 1.0  | 4.0  | 1.0  | 4.0  | 5.0  | 20.0 |
| 19  | Improve occupant health             | 2.0                         | 5.0  | 5.0  | 5.0  | 5.0  | 0.0  | 0.0  | 2.0   | 2.0  | 1.0  | 1.0  | 3.0  | 3.0  | 5.0  | 5.0  |
| 20  | Increase energy efficiency          | 2.2                         | 3.0  | 10.5 | 3.0  | 10.5 | 3.0  | 10.5 | 5.0   | 17.5 | 0.0  | 0.0  | 0.0  | 0.0  | 5.0  | 17.5 |
| 21  | Reduce energy consumption           | 2.5                         | 3.0  | 10.5 | 3.0  | 10.5 | 3.0  | 10.5 | 5.0   | 17.5 | 0.0  | 0.0  | 0.0  | 0.0  | 5.0  | 17.5 |
| 22  | Provide a secure energy supply      | 2.7                         | 3.0  | 10.5 | 3.0  | 10.5 | 3.0  | 10.5 | 5.0   | 17.5 | 5.0  | 17.5 | 2.0  | 6.5  | 5.0  | 17.5 |
| 23  | Facilitate renewable energy         | 3.4                         | 1.0  | 4.0  | 2.0  | 8.0  | 2.0  | 8.0  | 2.0   | 8.0  | 4.0  | 16.0 | 3.0  | 12.0 | 4.0  | 16.0 |
| 24  | Minimize environmental impact       | 3.8                         | 4.0  | 16.0 | 5.0  | 20.0 | 3.0  | 12.0 | 0.0   | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 4.0  | 16.0 |
| 25  | Increase carbon neutrality          | 2.9                         | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 1.0   | 1.0  | 3.0  | 3.0  | 1.0  | 1.0  | 3.0  | 3.0  |
| 26  | Reduce costs of carbon offset       | 2.7                         | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0   | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 3.0  | 3.0  |
| 27  | Meet regulatory requirements        | 3.3                         | 3.0  | 9.0  | 1.0  | 3.0  | 1.0  | 3.0  | 1.0   | 3.0  | 2.5  | 7.5  | 5.0  | 15.0 | 3.0  | 9.0  |
| 28  | Comply with policy or legislation   | 3.8                         | 3.0  | 15.0 | 5.0  | 25.0 | 5.0  | 25.0 | 3.0   | 15.0 | 5.0  | 25.0 | 3.0  | 15.0 | 5.0  | 25.0 |
| 29  | Diversify investment portfolios     | 1.9                         | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 0.0  | 1.5   | 4.5  | 3.0  | 6.0  | 0.0  | 0.0  | 5.0  | 10.0 |
| 30  | Leverage business platforms         | 3.1                         | 1.0  | 3.5  | 1.0  | 3.5  | 1.0  | 3.5  | 1.0   | 3.5  | 6.0  | 22.5 | 3.0  | 10.5 | 5.0  | 17.5 |
| Σ Technical Importance                              |                                     |                             | 366  |      | 335  |      | 227  |      | 355   |      | 285  |      | 331  |      | 473  |      |
| Relative Weight (1-5, 5 most important)             |                                     |                             | 5.0  |      | 4.6  |      | 3.1  |      | 4.8   |      | 3.0  |      | 3.5  |      | 5.0  |      |

Figure 37 – Environmental Compliance Manager HOQ

| House of Quality: Average Results, All Stakeholders Combined |                                     |                             |  |      |  |      |  |      |   |      |
|--|-------------------------------------|-----------------------------|--|------|--|------|--|------|---|------|
| Potential Stakeholder Requirements:                          |                                     | a. Importance (1 - 5 scale) | Technical Considerations (0-1-3-5-9 scale)                       |      |  |      |  |      |   |      |
|  |                                     |                             | b. Mechanical System Retrofits<br>b. Technical Importance (Mech) |      | c. Electrical System Retrofits<br>c. Technical Importance (Elec) |      | d. Plumbing System Retrofits<br>d. Technical Importance (Plumbing) |      | e. Building Enclosure Retrofits<br>e. Technical Importance (Envelope) |      |
| 1  | Reduce energy costs                 | 4.9                         | 6.2  | 30.5 | 4.5  | 22.5 | 6.0  | 10.4 | 4.8   | 24.1 |
| 2  | Increase return on investment       | 4.6                         | 5.4  | 25.4 | 4.2  | 20.0 | 5.3  | 10.2 | 3.8   | 17.8 |
| 3  | Minimize environmental impact       | 3.7                         | 4.5  | 17.2 | 3.4  | 13.2 | 4.4  | 13.6 | 3.1   | 11.8 |
| 4  | Improve your organization's image   | 3.1                         | 1.5  | 4.8  | 3.0  | 9.6  | 1.5  | 5.0  | 4.4   | 14.7 |
| 5  | Improve occupant comfort            | 3.5                         | 7.0  | 24.9 | 3.0  | 10.6 | 6.9  | 5.6  | 4.9   | 16.9 |
| 6  | Increase energy efficiency          | 4.5                         | 6.8  | 30.3 | 5.4  | 24.4 | 6.7  | 10.2 | 5.4   | 24.4 |
| 7  | Increase carbon neutrality          | 2.3                         | 4.4  | 11.2 | 4.4  | 11.0 | 4.4  | 2.0  | 3.5   | 9.1  |
| 8  | Achieve lower total ownership costs | 4.6                         | 5.9  | 27.8 | 4.6  | 21.2 | 5.9  | 14.8 | 4.7   | 22.7 |
| 9  | Meet regulatory requirements        | 4.7                         | 3.6  | 15.7 | 2.9  | 12.2 | 3.6  | 17.3 | 3.0   | 13.3 |
| 10   | Comply with policy or legislation   | 4.6                         | 5.0  | 23.2 | 5.1  | 23.2 | 5.0  | 18.7 | 3.7   | 17.2 |
| 11   | Improve aesthetic quality of site   | 2.3                         | 0.5  | 1.0  | 1.5  | 3.0  | 0.5  | 1.8  | 6.1   | 14.9 |
| 12   | Improve occupant productivity       | 3.7                         | 3.9  | 14.6 | 2.8  | 10.2 | 3.9  | 6.3  | 2.7   | 9.7  |
| 13   | Reduce chance of opposition         | 2.7                         | 1.9  | 6.3  | 2.3  | 7.9  | 1.9  | 6.3  | 3.6   | 11.2 |
| 14   | Increase property value             | 2.1                         | 3.1  | 7.1  | 2.4  | 6.0  | 3.0  | 5.5  | 4.8   | 11.7 |
| 15   | Reduce energy consumption           | 4.5                         | 7.1  | 31.9 | 5.5  | 25.9 | 6.9  | 10.6 | 4.9   | 22.3 |
| 16   | Provide a secure energy supply      | 3.4                         | 3.2  | 11.2 | 3.8  | 14.2 | 3.1  | 4.3  | 1.9   | 6.8  |
| 17   | Facilitate renewable energy         | 3.1                         | 3.5  | 11.2 | 4.1  | 13.4 | 3.5  | 4.6  | 3.2   | 9.7  |
| 18   | Lower project capital costs         | 3.4                         | 3.8  | 15.5 | 3.0  | 12.4 | 3.7  | 8.7  | 3.2   | 14.0 |
| 19   | Reduce costs of carbon offset       | 2.0                         | 3.8  | 8.4  | 4.0  | 8.9  | 3.7  | 2.5  | 2.9   | 6.7  |
| 20   | Achieve higher rental rates         | 2.2                         | 2.4  | 5.9  | 2.1  | 5.5  | 2.4  | 4.9  | 3.7   | 9.3  |
| 21   | Achieve higher occupancy rates      | 2.5                         | 3.3  | 7.9  | 2.4  | 6.4  | 3.3  | 5.7  | 3.7   | 10.2 |
| 22   | Avoid costs due to opposition       | 2.7                         | 1.6  | 5.0  | 1.6  | 5.1  | 1.6  | 5.9  | 2.9   | 9.2  |
| 23   | Gain the public's trust             | 3.4                         | 1.3  | 4.4  | 1.4  | 5.2  | 1.2  | 5.1  | 2.3   | 8.1  |
| 24   | Decrease outages / interruptions    | 3.8                         | 4.9  | 19.3 | 4.9  | 19.4 | 4.9  | 12.4 | 1.1   | 4.2  |
| 25   | Attract and retain employees        | 2.9                         | 2.2  | 7.4  | 1.9  | 6.6  | 2.1  | 5.6  | 3.3   | 11.7 |
| 26   | Improve occupant attendance         | 2.7                         | 3.0  | 10.6 | 1.9  | 6.5  | 2.9  | 6.1  | 2.1   | 7.5  |
| 27   | Improve occupant health             | 3.3                         | 5.0  | 17.2 | 1.9  | 6.7  | 5.0  | 7.9  | 2.3   | 8.3  |
| 28   | Improve corporate reporting results | 3.8                         | 3.0  | 12.1 | 3.7  | 15.7 | 3.0  | 13.1 | 3.3   | 13.8 |
| 29   | Diversify investment portfolios     | 1.9                         | 1.4  | 3.2  | 1.3  | 2.7  | 1.4  | 2.5  | 1.7   | 4.1  |
| 30   | Leverage business platforms         | 3.1                         | 2.2  | 7.6  | 1.9  | 7.4  | 2.1  | 4.2  | 1.8   | 6.0  |
| Σ Technical Importance                                       |                                     |                             | 419  |      | 357  |      | 231  |      | 371   |      |
| Relative Weight (1-5, 5 most important)                      |                                     |                             | 5.00   |      | 4.26   |      | 2.76   |      | 4.43  |      |
| Σ Occupant Satisfaction Points                               |                                     |                             | 71.667   |      | 55.75  |      | 68.75  |      | 72.00   |      |
| Relative Weight (1-5, 5 least satisfied)                     |                                     |                             | 4.98   |      | 3.87   |      | 4.77   |      | 5.00  |      |

Figure 38 – HOQ for Technical Considerations, Equal Stakeholder Group Representation. As seen in Figure 14, provided once again for the purpose of the following sample calculations.

**Figure 38 Sample Calculations:**

**Steps 1 & 2:** Average importance for the stakeholder requirement to meet regulatory requirements

**Steps 3, 4, & 5:** Technical importance of electrical system retrofits in meeting regulatory requirements

**Steps 5 & 6:** Relative weight for electrical system retrofits

**Variables:**

$i$  = row = stakeholder requirements  
(what,  $i = 1$  to 30)

$t$  = tenants

$j$  = column = technical retrofit measures  
(how,  $j = b$  to  $e$  or  $f$  to  $h$ )

$o$  = owners

$k$  = stakeholder group

$fm$  = facility managers

$l$  = individual HOQ participant

$d$  = designers

$q$  = number of stakeholder requirements

$ev$  = environmental managers

$r$  = number of technical retrofit measures

$I$  = importance rating

$n$  = number of participants in each stakeholder group

$R$  = relationship rating

$N$  = number of stakeholder groups

$TI$  = technical importance

$RW$  = relative weight

**Step 1:** Calculate the average importance ( $I$ ) according to each stakeholder group ( $k$ ), for each stakeholder requirement ( $i$ ).

$$(\bar{I}_k)_{i=} = \frac{\sum_{l=1}^n (I_l)_i}{n}$$

$$(\bar{I}_t)_9 = 3.7; (\bar{I}_o)_9 = 4.2; (\bar{I}_{fm})_9 = 4.5; (\bar{I}_d)_9 = 3.6; (\bar{I}_{ev})_9 = 5.0$$

(above averages calculated in Appendix B)

**Step 2:** Calculate the average importance ( $I$ ) for all stakeholder groups combined, using procedures that equally account for the perceptions of each stakeholder group as described in Section 4.6.1.

$$\bar{I}_9 = \frac{\sum_{k=1}^N (\bar{I}_k)_9}{N} = \frac{3.7 + 4.2 + 4.5 + 3.6 + 5}{5} = 4.2$$

**Step 3:** Calculate the technical importance ( $TI$ ) for each individual participant using EQ (1).

$$\text{Individual } TI_{(i,j)} = I_i \times R_{(i,j)}$$

(individual  $TI$  calculations ( $TI_{(9,c)}$ ) for the ability of electrical system retrofits ( $j = c$ ) in meeting regulatory requirements ( $i = 9$ ) are provided in Table 28 of Appendix D)

**Step 4:** Calculate the average  $TI$  for each stakeholder group ( $k$ ) using EQ. (1).

$$(\overline{TI}_k)_{(i,j)} = \frac{\sum_{l=1}^n (TI_l)_{(i,j)}}{n}$$

$$(\overline{TI}_t)_{(9,c)} = 10.7; (\overline{TI}_o)_{(9,c)} = 14.2; (\overline{TI}_{fm})_{(9,c)} = 25.3; (\overline{TI}_d)_{(9,c)} = 5.9; (\overline{TI}_{ev})_{(9,c)} = 5.0$$

(average  $TI$  calculated in Table 29 of Appendix D)

**Step 5:** Calculate the average *TI* of all stakeholder groups combined using procedures that equally account for the perceptions of each stakeholder group as described in Section 4.6.1.

$$\overline{TI}_{(9,c)} = \frac{\sum_{k=1}^N (\overline{TI}_k)_{(9,c)}}{N} = \frac{10.7 + 14.2 + 25.3 + 5.9 + 5.0}{5} = 12.2$$

**Step 6:** Calculate the sum of *TI* for all 30 stakeholder requirements (*i*) and each technical retrofit measure (*j*) using EQ. (2).

$$\sum_{i=1}^q TI_{(c)} = 357$$

( $\sum TI_{(c)}$  was calculated in Figure 38 on page J-7)

**Step 7:** Calculate *RW* for each technical retrofit measure (*j*) using EQ. (3).

$$RW_j = \frac{TI_j \times 5}{TI_{\max_{j=1 \text{ to } r(j)}}} \quad (\text{Max } TI_j \text{ from columns b, c, d, e; or f, g, h})$$

$$RW_{(c)} = \frac{357 \times 5}{419} = 4.26$$

( $TI_{\max}$  and *RW* calculated in Figure 38 on page J-7)

## **Appendix K – Occupant Satisfaction Survey**

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**Introduction**

Dear Participant,

On behalf of the Department of Civil and Environmental Engineering at the University of Wisconsin-Madison, I am pleased to invite you to complete a survey which will be part of a research project that assesses decisions to implement sustainable retrofits in existing buildings.

The project is collecting data about perceptions of sustainable retrofits, and this survey is assessing participant satisfaction with Admiral Boorda Hall as an example case study. This will help identify the most important aspects of the Building 30 to focus on if it were to be potentially renovated in the future, and will be an advantage to all in future decision making.

The survey is intended to be completed by participants such as building tenants, owners, operators, service providers, contractors, engineers, guests, or anyone else that has an interest in the condition of the building.

Thank you for your valuable contribution to this important study.

---

**Occupant Satisfaction Survey**

Section 2: Building Satisfaction Survey.

This occupant satisfaction survey will help identify the most important aspects of Building 30 to focus on if it were potentially renovated in the future.

---

How satisfied are you with the overhead lighting in your workspace?

---

- Very Satisfied
- Satisfied
- Somewhat Satisfied
- Not Very Satisfied
- Dissatisfied

Why are you less than satisfied with your overhead lighting, please explain?

---

How satisfied are you with the task lighting in your workspace?

---

- Very Satisfied

- Satisfied
- Somewhat Satisfied
- Not Very Satisfied
- Dissatisfied
- There is no task lighting, and I would like to have task lighting
- There is no task lighting, and I do not need it

Why are you less than satisfied with your task lighting, please explain?

---

How comfortable is the day lighting in your workspace?

---

- Very Comfortable
- Comfortable
- Somewhat Comfortable
- Not Very Comfortable
- Uncomfortable
- There is no day lighting in my workspace

Why are you less than satisfied with the day lighting in your workspace, please explain?

---

How satisfied are you with the heating around your workspace?

---

- Very Satisfied
- Satisfied
- Somewhat Satisfied
- Not Very Satisfied
- Dissatisfied

Why are you less than satisfied with your heating, please explain?

---

How reliable is the heating around your workspace?

---

- Very Reliable
- Reliable
- Somewhat Reliable
- Not Very Reliable
- Unreliable

How satisfied are you with the cooling around your workspace?

---

- Very Satisfied
- Satisfied
- Somewhat Satisfied
- Not Very Satisfied
- Dissatisfied

Why are you less than satisfied with your cooling, please explain?

---

How reliable is the cooling around your workspace?

---

- Very Reliable
- Reliable
- Somewhat Reliable
- Not Very Reliable
- Unreliable

Indoor Environmental Quality refers to your surroundings in your workspace, specifically elements that may affect one of the five senses: touch, sight, sound, smell, or taste.

Key elements to consider when evaluating the Indoor Environmental Quality include sound disturbances from the outside, temperature, humidity, air movement from window/door/wall drafts, or air contaminants from inside or outside sources.

In general, how satisfied are you with the Indoor Environmental Quality around your workspace?

---

- Very Satisfied
- Satisfied
- Somewhat Satisfied

- Not Very Satisfied  
 Dissatisfied

Which of these indoor environmental quality items are you dissatisfied with?

|   | Select all that apply    |
|---|--------------------------|
| sound disturbances from the outside (if applicable)             | <input type="checkbox"/> |
| temperature (if applicable)                                     | <input type="checkbox"/> |
| humidity (if applicable)  | <input type="checkbox"/> |
| air movement from a window, wall, or door draft (if applicable) | <input type="checkbox"/> |
| air contaminants from the outside or inside (if applicable)     | <input type="checkbox"/> |

How satisfied are you with the plumbing service to and from your building?

- Very Satisfied  
 Satisfied  
 Somewhat Satisfied  
 Not Very Satisfied  
 Dissatisfied

Why are you less than satisfied with the plumbing service in your building, please explain?

How reliable is the plumbing service to and from your building?

- Very Reliable  
 Reliable  
 Somewhat Reliable  
 Not Very Reliable  
 Unreliable

How satisfied are you with the hot water service in your building?

- Very Satisfied
- Satisfied
- Somewhat Satisfied
- Not Very Satisfied
- Dissatisfied

Why are you less than satisfied with the hot water in your building, please explain?

How reliable is the hot water service in your building?

- Very Reliable
- Reliable
- Somewhat Reliable
- Not Very Reliable
- Unreliable

How satisfied are you with the electrical power in your building?

- Very Satisfied
- Satisfied
- Somewhat Satisfied
- Not Very Satisfied
- Dissatisfied

Why are you less than satisfied with the electrical power in your building, please explain?

How reliable is the electrical power in your building?

- Very Reliable
- Reliable
- Somewhat Reliable
- Not Very Reliable
- Unreliable

**Participant Information****Section 3:**

We are interested in identifying the primary requirements and perceptions for pursuing **sustainable building retrofits** from different types of individuals working in various roles.

Please provide us with some information that will help us identify what type of interest or association that you have with Building 30.

---

What organization, business, department, division, and/or branch, etc..., do you work for?

---

What is your organizations interest concerning the building? (housing, employee, maintenance, service provider, resident, contractor, etc...)

---

Please give a brief description of your job.

---

If you work in the building, do you work in an open office space or in a private office?

---

- Open
- Private
- I do not occupy an office space in this building

How many hours per day do you spend in the building?

(please enter only numbers)

---

What room number do you occupy or work out of? - IE. Ste 101, Room 245, and/or mechanical room, conference room, classroom)

---

Name (optional):

---

Email address (optional):

---

## **Appendix L – Data and Calculations: Occupant Satisfaction Survey**

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***Table 43 Sample Calculation: Relative Weight for Occupant Satisfaction with Plumbing System***

- 4 – Questions were asked pertaining to rating the satisfaction with building’s plumbing system components.
- The scale was 1 to 5, with 5 being most dissatisfied.
- The total amount of points for the 5-plumbing system questions amounted to 275 (out of 600 possible points = 4 questions x 30 participants x 5 points per question).
- Supporting data is available in Table 46 above.

$$\Sigma \text{Occupant Satisfaction Points (plumbing)} = 275$$

$$\text{Average Occupant Satisfaction (plumbing)} = \frac{275}{4 \text{ questions}} = 68.75$$

- Average Occupant Satisfaction points for all systems: mechanical = 71.67, electrical = 55.75, plumbing = 68.75, envelope = 72.0; maximum value = 72.0 (See Table 46 above)

$$\text{Relative Weight (plumbing)} = \frac{68.75 \times 5}{72.0} = 4.77$$

## **Explanations for Dissatisfaction Provided by Survey Participants:**

**Question 2.2 A:** Why are you less than satisfied with your overhead lighting, please explain?

- Participant # 7 Response: Not sufficient! Very dark room.
- Participant # 10 Response: The bedrooms have no overhead light; They have wall sconces with really poor eye' level light. Kitchen could use task lighting.

**Question 2.3 A:** Why are you less than satisfied with your task lighting, please explain?

- Participant #3 Response: there is no task lighting and I don't need it.
- Participant #6 Response: there is no task lighting and I would like task lighting.
- Participant #7 Response: Doesn't cover entire desk working area.
- Participant #10 Response: there is no task lighting and I would like task lighting.
- Participant #12 Response: There is no task lighting and I do not need it.
- Participant #13 Response: lighting in the main room is poor. needs to be brighter.
- Participant #17 Response: There is no task lighting and I do not need it.
- Participant #22 Response: Too dim, prefer white fluorescent light if possible.
- Participant #27 Response: There is no task lighting and I do not need it.

**Question 2.4A:** Why are you less than satisfied with the day lighting in your workspace, please explain?

- Participant #20 Response: our work space is almost 60 percent surrounded with glass get really hot during the summer time.

**Question 2.5A:** Why are you less than satisfied with your heating, please explain?

- Participant #2 Response: Base temp set points limit what residents can set temp too.
- Participant #4 Response: The building is cold. The single-paned windows are not adequate to keep the cold at bay and there are drafts that come in through the windows, outlets, and under the doors.
- Participant #5 Response: The windows are thin and the cold winter air comes right through them. with the thermostat in the location that it is it doesn't get a true temperature reading in the part of the room that is occupied the most.
- Participant #7 Response: Because the windows are so big and old they radiate the cold. Half the room is warm, but the half next to the windows is chilly.
- Participant #11 Response: Because it is always cold in the room and I cannot adjust my own temperature or buy a portable heater due to safety.

- Participant #12 Response: I cannot adjust my own temperature, it is cold and I think it is less than 68 degrees that the Navy allows.
- Participant #13 Response: thermostat is over the heat vent. Air is VERY DRY. uneven heat across room.
- Participant #18 Response: I cannot adjust, the thermostat is by the heat vent. It is cold by the wall and window.
- Participant #25 Response: Old HVAC systems. We tend to do "Band-Aid" repairs.
- Participant #26 Response: not enough heat:(

**Question 2.7A:** Why are you less than satisfied with your cooling, please explain?

- Participant #2 Response: Instead of system overhaul, we fix what is broke only, causing constant attention to HVAC systems.
- Participant #3 Response: Issues related to policy and the HVAC system. Policy: DoD/Navy set points regulate how cool or warm the temperature is. While I understand the policy for the workplace, I think it's a horrible deal for the residents. If the Navy required family housing to meet the same set points as unaccompanied housing there would be a riot. It's aggravated by what seems an overly complex system that has never been able to balance temperature throughout the building, despite a very expensive project to fix the HAVC system a few years ago. Adding insult to injury are the temperature controls installed in resident rooms that cause nothing but frustration when the residents realize all it controls is the fan and they have virtually no control over the temperature in their room.
- Participant #4 Response: The cooling system is not adequate to keep the rooms cool. Other measures are often taken to ensure comfort (i.e. portable and ceiling fans).
- Participant #5 Response: location of the thermostat does not give an accurate reading of what the room temp is in the actual living area.
- Participant #18 Response: Thermostat is in the wrong place and runs for a long time. It is hot in the room. I cannot adjust my own cooling.
- Participant #20 Response: our cooling system is set to certain temp.AC wont kick in until outside temp reach 78 degrees.
- Participant #25 Response: Old HVAC systems. Same as heating, we tend to only fix when it breaks. Need to do PM.
- Participant #26 Response: not enough or nothing at all:(

**Question 2.10A:** Why are you less than satisfied with the plumbing service in your building, please explain?

- Participant #3 Response: Plumbing for public use is fine. new water saving toilets installed last year in resident rooms are prone to breaking and have created a number of maintenance problems.
- Participant #6 Response: too many leaks, pipes sweat causing ceiling tile to get ruined.

- Participant #12 Response: Hot water takes forever to heat up, if at all, especially in the morning when everyone is showering.
- Participant #20 Response: there's always clogged problem, the piping in this barracks are way too small for the occupants that we have.
- Participant #22 Response: Latrines can sometimes get clogged up easily.
- Participant #25 Response: Design of building and Energy Efficiency "upgrades" limit the temp and water flow. Many complaints from residents on this.

**Question 2.12A:** Why are you less than satisfied with the hot water in your building, please explain?

- Participant #2 Response: Design of the building causes some rooms to take too long for the hot water to reach them.
- Participant #4 Response: It takes quite a while for the hot water to actually get hot...wasting a lot of water in the process. Sometimes, it just remains lukewarm.
- Participant #6 Response: some cases hot water temp is not hot to certain residents, time of shower & which end of building.
- Participant #11 Response: It takes the water 15 minutes to heat up so not only does it waste time, it wastes water as well.
- Participant #12 Response: Hot water takes forever to heat up, especially in morning.
- Participant #18 Response: It takes a long time for shower to heat up. Sometimes it doesn't get hot. I waste a lot of water.
- Participant #20 Response: pressure is low. sometimes it will take 30. minutes to run the water before you get hot water.
- Participant #25 Response: Takes too long for water to heat up in some parts of building.

Table 47 – Occupant Satisfaction Survey Participant Information Data

| Question #: | V8              | V9              | 3.3  | 3.4  | 3.5  | 3.6  | 3.7  | 3.8  |
|-------------|-----------------|-----------------|--|--|--|--|--|--|
| Participant | StartDate       | EndDate         | What organization, business, department, division, and/or branch, etc..., do you work for? | What is your organizations interest concerning the building? (housing, employee, maintenance, servc... | Please give a brief description of your job. | If you work in the building, do you work in an open office space or in a private office? | How many hours per day do you spend in the building? / (please enter only numbers) | What room number do you occupy or work out of? -IE. Ste 101, Room 245, and/or mechanical room, conf... |
| 1           | 1/27/2012 14:05 | 1/27/2012 14:09 | NAVAC PWD<br>Unaccompanied Housing   | PW Functions<br>Employee   | APWO<br>Complex Manager. Oversee B           | 3<br>2   | 1<br>9   | B-3, Room 204<br>109   |
| 2           | 1/27/2012 14:35 | 1/27/2012 14:44 | NAVSTA Great Lakes<br>Unaccompanied Housing  | Service provider/maintenance   | Installation and Region<br>Program Manager   | 2  | 8  | 31.102   |
| 3           | 1/27/2012 15:23 | 1/27/2012 15:47 | USN / RTC Great Lakes  | Resident   | Recruit Division Commander                   | 3  | 38   | 30-612   |
| 4           | 1/30/2012 6:47  | 1/30/2012 7:03  | CSCS Great lakes.  | housing  | Departmental LCPO                            | 3  | 12   |  |
| 5           | 1/30/2012 10:27 | 1/30/2012 10:35 | unoccupied housing   | maintenance  | building manager                             | 3  | 8  | 4th deck maintenance room  |
| 6           | 2/2/2012 6:54   | 2/2/2012 7:09   | Naval Station Great Lakes, Unaccompanied Housing   | Housing service provider   | I am a Active Duty Officer work              | 2  | 8  | Bldg.30, room 111  |
| 7           | 2/2/2012 12:49  | 2/2/2012 13:00  | Unaccompanied Housing  | Resident   | Building Manager                             | 2  | 8  | 112  |
| 8           | 2/2/2012 12:55  | 2/2/2012 13:05  | Naval health clinic.great lakes  | residents, barracks.   | Personnel specialist                         | 3  | 16   | 302  |
| 9           | 2/2/2012 13:11  | 2/2/2012 13:21  | NAVAC PWD Graet Lakes  | Housing  | Construction manager                         | 1  | 12   | 30.604   |
| 10          | 2/2/2012 13:18  | 2/2/2012 13:25  | Navy   | resident   | RDC  | 3  | 8  | 713  |
| 11          | 2/2/2012 17:46  | 2/2/2012 17:54  | Navy   | resident   |  | 3  | 10   |  |
| 12          | 2/2/2012 20:44  | 2/2/2012 20:48  | NAVY   |  | CMDCM  | 3  | 12   | standard barracks room   |
| 13          | 2/3/2012 7:45   | 2/3/2012 8:59   | unaccompanied housing  | maintenance,service provider   | Building manager asst                        | 1  | 8.5  | all rooms  |
| 14          | 1/30/2012 10:08 | 2/3/2012 10:49  |  |  |  |  |  |  |
| 15          | 2/7/2012 12:02  | 2/7/2012 12:05  |  |  |  |  |  |  |
| 16          | 1/27/2012 13:53 | 1/27/2012 13:57 |  |  |  |  |  |  |
| 17          | 1/29/2012 19:40 | 1/29/2012 19:45 | NAVY   | resident   |  | 3  | 10   |  |
| 18          | 2/8/2012 8:59   | 2/8/2012 9:02   |  |  |  |  |  |  |
| 19          | 1/30/2012 9:52  | 1/30/2012 9:52  | unaccompanied housing  | housing for sailor   | front desk supervisor                        | 2  | 8  | office 104   |
| 20          | 2/8/2012 12:53  | 2/8/2012 13:09  |  |  |  | 1  |  |  |
| 21          | 2/8/2012 15:28  | 2/8/2012 15:34  | Unaccompanied Housing  | Housing  |  | 2  | 8  |  |
| 22          | 2/9/2012 8:16   | 2/9/2012 8:23   |  |  |  |  |  |  |
| 23          | 2/9/2012 8:51   | 2/9/2012 8:59   |  |  |  |  |  |  |
| 24          | 2/2/2012 12:42  | 2/2/2012 12:42  | UH   | Housing, employee, maintenai   | Maintenance                                  | 2  | 8  | 112  |
| 25          | 2/15/2012 8:12  | 2/15/2012 8:19  | Unaccompanied Housing/MWR  | Employee   | Front Desk Clerk/ assist custom              | 1  | 8  | 104  |
| 26          | 2/15/2012 8:19  | 2/15/2012 8:33  | Bachelor Housing   | Employee   | housing service provider                     | 1  | 8  |  |
| 27          | 2/17/2012 7:32  | 2/17/2012 7:34  | Navy, maintenance  | maintenance  | maintenance                                  | 3  | 3  |  |
| 28          | 2/17/2012 7:34  | 2/17/2012 7:36  | Bachelor Housing   | occupant   | cmc  | 2  |  |  |
| 29          | 2/17/2012 9:20  | 2/17/2012 9:22  | bachelor housing   | employee   | maintenance                                  | 3  | 10   |  |
| 30          | 2/17/2012 9:22  | 2/17/2012 9:23  |  |  |  |  |  |  |

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