Improving the Green Building Standards in Hong Kong

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Abstract

This project, sponsored by the Hong Kong Green Building Council, focused on improving the green building standards in Hong Kong by reviewing the Building Environmental Assessment Method (BEAM) Plus scheme. We identified that the problems between the theoretical and actual implementation of BEAM Plus are caused by low occupant awareness and infrequently achieved standards related to green technologies. Our recommendations aim to increase occupant awareness and stimulate interest in implementing green features.

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Authorship Page

Contents	Primary Author
Title Page	Francois
Acknowledgements	Jenny
Authorship Page	All
Table of Contents	Borong
Table of Figures	Borong
Table of Tables	Borong
Executive Summary	Tobin
Abstract	Francois
Introduction	All
Background	All
2.1	Tobin, Francois, Borong
2.2	Borong, Tobin
2.3	Francois
2.4	Jenny
2.5	Jenny
Methodology	Borong
3.1	All
3.2	All
3.3	All
3.4	Borong
Results & Analysis	Tobin
4.1	All
4.2	Jenny, Tobin, Francois
4.3	Borong
4.4	Borong
Conclusion2&Recommendations	Tobin
5.1	Tobin, Borong
5.2	Tobin, Francois, Borong
5.3	Jenny
5.4	Tobin
5.5	Francois
5.6	All
Reference	All
Appendix A	Borong
Appendix B	Tobin
Appendix C	Borong

Contents	Primary Author
Appendix D	Tobin
Appendix E	Borong
Appendix F	Francois
Appendix G	Francois
Appendix H	Borong
Appendix I	Borong
Appendix J	Borong
Appendix K	Borong
Appendix L	Jenny
Appendix M	Jenny
Appendix N	Jenny
Appendix O	Jenny
Appendix P	Jenny
Appendix Q	Jenny
Appendix R	Jenny
Appendix S	Jenny, Borong
Appendix T	All
Appendix U	All

All members of our team are primary editors for all sections of the report.

Table of Contents

Table of Figures

Table of Tables

Executive Summary

Climate change and environmental degradation are among the most pressing issues in the world today. National energy reports have indicated that the building sector is a major contributor to Green House Gas (GHG) emissions and consumes 40% of the globe's total energy (AGC of America, 2009; Wang, 2012; Andrews, 2014). To respond to the demand for more sustainable buildings, many building environmental assessment rating tools have been developed to guide the construction of 'greener' buildings, such as LEED, BREEAM, BCA Green Mark, and BEAM Plus. Hong Kong employs BEAM Plus, and since 1996, there have been serious efforts to improve the standard of sustainable buildings in Hong Kong (BEAM Society, 2012c). The Hong Kong Green Building Council (HKGBC) is constantly modifying BEAM Plus to continuously enhance the standard of sustainable buildings in Hong Kong, but it is not fully understood what the fundamental flaws in the BEAM Plus scheme might be. The HKGBC also has neither researched into the public awareness of green buildings of the public nor the satisfaction of occupants in certified BEAM Plus buildings. The HKGBC wants to study where BEAM Plus can be improved to guide Hong Kong to a more environmentally sustainable future.

Designing and erecting green buildings in Hong Kong must be done thoughtfully to align with the city's subtropical-climate and infrastructure. BEAM Plus has an assembled list of credits that pushes projects towards sustainable practices while providing feasible targets to be achieved. These credits must be general enough to inspire innovation, but specific enough to encourage projects to implement more sustainable practices.

The goal of this project was to suggest modifications to BEAM Plus to stimulate the building standards in Hong Kong toward sustainability. Our first objective was to identify the strengths and weaknesses of the BEAM Plus scheme. We analyzed 216 BEAM Plus assessed projects by cataloguing the achievement status of all credits. Another objective was to determine how BEAM Plus certified buildings have maintained installed green technologies since operation. We attended public tours of two buildings of the highest BEAM Plus certification level to the study their maintenance of green features. To appreciate the inherent challenges and benefits of operating a BEAM Plus certified building, we interviewed three separate anonymous building managers. Our final objective was to determine the public's opinions and perceptions of BEAM Plus certified buildings. We surveyed occupants of two BEAM Plus certified universities with questions about their personal comfort and knowledge of green buildings. These analyses and observations guided us to form suggestions about modifications to the BEAM Plus scheme to prompt progress with environmental standards in Hong Kong buildings.

We concluded that while BEAM Plus provides strong management tools for projects, it struggles to promote usage of green technologies. Occupants demonstrated limited understanding of green buildings, which inhibited them from effectively using green features available in buildings. Our recommendations can strengthen BEAM Plus standards to enhance sustainability of Hong Kong buildings and develop education about green buildings for the public.

1. Introduction

Climate change and environmental degradation are among the most pressing issues in the 21st century. National energy reports indicate that the building sector is a major contributor to Green House Gas (GHG) emissions and consumes 40% of the globe's total energy (AGC of America, 2009; Wang, 2012; Andrews, 2014). Increasing the number of sustainable, energy efficient buildings can help reduce wasteful processes and energy consumption. Following benchmark objectives of environmental assessment schemes can stimulate the building industry toward embracing green building standards (Cole, 2012).

The demand for more green buildings in Hong Kong has risen as pollution and air quality have worsened (BEAM Society, 2012a). Our sponsor, Hong Kong Green Building Council (HKGBC) (2014), is an organization focused on promoting and developing the standards of sustainable buildings in Hong Kong. The HKGBC uses the green building certification tool, BEAM Plus, as a cost-effective management tool to inspire the efficient use of energy and resources in buildings. However, how BEAM Plus certified buildings actualize the standards during operation, and even how occupants interact with green features, is not fully understood.

Environmental performance of BEAM Plus certified buildings is relative to Hong Kong's specific infrastructure, air quality, and subtropical climate. With limited habitable space, there are many high-rise buildings in Hong Kong to accommodate its high population, which presents unique pressures on the environment (Yau, Lau, & Choi, 2014). In response, BEAM Plus has been continuously modified to fully address Hong

Kong's distinct environmental problems, including pollution and energy consumption (BEAM Society, 2012a).

The HKGBC is investigating how achievable BEAM Plus credits are and if green buildings provide comfortable environments for their occupants. A research project carried out in early 2014 studied the strengths and weaknesses of BEAM Plus credits through archival research of 110 assessment reports, field surveys, and focus groups (Crespi, Rangle, Webb, & Zhang, 2014). However, there is still not enough research about maintenance of BEAM Plus certified buildings, or how buildings may deviate from original designs. There is also a lack of information about how successful people are at adapting to living and working in BEAM Plus buildings.

The goal of this project was to suggest modifications to credits within the BEAM Plus rating tool to stimulate improvements in environmental building standards of buildings in Hong Kong. By conducting archival research, public tours, and building manager interviews, we concluded that while BEAM Plus provides strong management tools for projects, it struggles to promote usage of green technologies. Surveys revealed that occupants had limited understanding of green buildings, which inhibited them from effectively using green features available in buildings. Our recommendations can strengthen BEAM Plus standards to enhance sustainability of Hong Kong buildings and develop education about green buildings for the public.

2. Background

Evidence of climate change and environmental degradation in the past few decades has led to growing public demand to substitute wasteful processes for more sustainable practices. Buildings have contributed to these major global issues due to the tremendous amount of electricity that they consume and pollution that they produce (AGC of America, 2009; Wang, 2012; Andrews, 2014). To create more sustainable buildings and reduce the energy consumption and pollution of buildings, environmental assessment rating tools for buildings have been developed across the globe (Yau, Lau, & Choi, 2014; Haapio & Viitaniemi, 2008; Ding, 2008). In this chapter we will discuss and review different aspects of environmental rating assessment tools and various challenges that they face with environmental assessment.

2.1 Environmental assessment rating tools

The building sector started to become concerned about the ramifications of the environmental impacts of buildings in the 1990s during discussions of escalating gas prices and changing climates (Haapio & Viitaniemi, 2008; Wong, 2014). "Buildings embody and consume among the largest fraction of energy within the built environment, and likewise they are responsible for large emissions of greenhouse gases (GHGs), often referred to as their carbon footprint" (Eboli, Mitchell, Ryberg, Spatari, & Stadel, 2011, p. 51). Significant changes were needed to mitigate the environmental impact of the building sector (Haapio & Viitaniemi, 2008). Many organizations, such as the HKGBC, formed around the globe with the initiative to promote more sustainable practice in buildings and focus on balancing energy, environment and ecology (Ding, 2008).

Environmental assessment methods are used to measure the environmental impact of a building, although because each type of building, such as residential or industrial, consumes energy differently and serves their occupants uniquely, no one method is universally applicable (Haapio, 2008). "The emergence and evolution of building environmental assessments responds to a tension between the desire for objective, scientifically rigorous and stringent performance criteria with the desire for practical, transparent, simple to understand criteria that ask the industry to respond to manageable step changes in practice. Building environmental assessment methods were conceived as being voluntary and motivational in their application and their current success" (Cole, 2012, p.1). Generally, there is debate over 'building standards'; environmentalists are propelling conversation of sustainable practices that benefit both human occupants and the local ecology, while stakeholders will prefer economic buildings over comfortable and sustainable ones (Haapio, 2008). Despite conflicting interests, environmental assessment tools have been successful in establishing environmentally conscious practices and have helped address a set of significant environmental problems (Cole, 2012).

This projects concerns itself with a specific building environmental assessment method, BEAM Plus, which is a scheme document designed to guide the construction or renovation of a building (BEAM Society, 2012a). In this section, we will introduce three similar Environmental Assessment Methods used elsewhere: BREEAM, LEED and BCA Green Mark.

2.1.1 BREEAM - United Kingdom

Building Research Establishment Environmental Assessment Method (BREEAM) (2014), launched in 1990 in the United Kingdom, was the first environmental assessment method and rating system for buildings in the world. Now there are 250,000 BREEAM certified buildings and over a million registered for assessment.

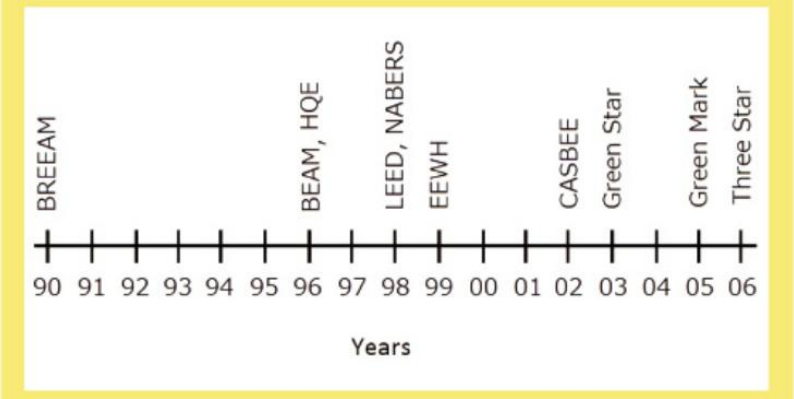


Figure 2.1: Launch dates for major green building rating tools that are still in use today (Yau, Lau, & Choi, 2014)

The BREEAM was launched as a credit award system for new office buildings, used to check and evaluate buildings from a list of environmental criteria based on a single scale of fair, good, very good or excellent (Ding, 2008). Buildings typically develop around the BREEAM criteria after initial designs have already been established, and are modified accordingly, allowing for flexibility in design. BREEAM has been updated frequently and extended to include assessments for existing buildings.

BREEAM has made a large impact in the world, and it has been the model for Hong Kong, Canada, Australia, France and other countries to develop their own environmental assessment methods (Lee & Burnett, 2008). The concept of the BREEAM assessment method, a mixture of performance-based and feature-specific criteria, is directly followed by HK-BEAM. HK-BEAM is largely based on the BREEAM version

1/93, with modifications to suit the characteristics of the environment in Hong Kong, such as numerous high-rise buildings and its subtropical climate.

2.1.2 LEED - United States

LEED (Leadership in Energy and Environmental Design) is a third party verification system that has become a method of standardization for environmental performance of new and existing commercial, institutional, and residential buildings (USGBC, 2012). Launched in the USA in 1998, this rating tool has quickly spread to become one of the major international green-building standards. What started as a USA product created by the United States Green Building Council (USGBC) has spread to nearby countries such as Canada, and now is heavily influential in countries such as India and China.

Perhaps the most world-renowned environmental rating tool, LEED has completely reshaped the face of sustainable green building design from the year 2000 onwards (Richards, 2012). LEED's focus is to improve the green building performance as a response to escalating gas and oil prices, rising carbon and GHG emissions, climate change, and rising utility costs. The rating tool focuses on sustainable site development, water savings, energy efficiency, materials selection, and indoor environmental quality. LEED targets both private and public sectors: homes, neighborhood development, commercial interiors, core and shell, new construction, existing buildings, schools, retail, and healthcare. The popularity of LEED has spread to become a standard for buildings' environmental standards, even influencing some municipal and county building codes to require LEED certification to develop more energy efficient buildings. Evidence has shown that LEED buildings are 40% more energy efficient than non-certified buildings.

LEED is continuously under development to respond to criticism that LEED is too standardized to address local environmental conditions as it expands internationally. Some critiques of LEED buildings are that they may be more energy efficient, but they do not lower energy consumption rates compared to non-LEED buildings (Scofield, 2013). Yet LEED continues readjusting its goals to better respond to escalating environmental concerns. For example, in 2004 when escalating gas and oil prices were troublesome, LEED required a 30% rise in energy efficiency from LEED certified buildings. LEED's initiative and ubiquity has led the world forward in the face of environmental degradation (Richards, 2012).

2.1.3 BCA Green Mark - Singapore

The Building and Construction Authority Green Mark, launched in 2005, is a green building rating system used to evaluate a building for its environmental impact and performance in Singapore (BCA, 2014a). Endorsed and supported by Singapore's National Environment Agency, it serves as an initiative to drive Singapore's construction industry towards more environmental-friendly buildings (BCA, 2014b). The Green Mark scheme provides a comprehensive framework for assessing the overall environmental performance and impact of new and existing buildings within Singapore. By promoting sustainability in buildings, Green Mark intends to raise the environmental consciousness of the building developers, designers, and builders alike. The promotion of sustainability is expected during the conceptualization phase of a project, in its design phase, and in the construction of the building.

The BCA Green Mark is a benchmarking scheme that incorporates the best internationally recognized practices in environmental design and performance (BCA,

2014a). Using this scheme benefits the real estate market with a positive image because they can market sustainable buildings. The scheme's mission is facilitation of the reduction of water and energy bills, reduction of potential environmental impact, and improvement of indoor environmental quality (indoor air quality) for a healthy and productive workplace. it also provides clear direction for continual improvement.

Using this assessment method, developers and designers are encouraged to not only design green but to construct green, sustainable buildings that promote energy and water savings, healthier indoor environments, and adoption of greenery for their projects (BCA, 2014b). The assessment covers the following criteria: energy efficiency, water efficiency, environmental protection, indoor environmental quality (indoor air quality), and other green features and innovations. It identifies the energy efficient and environmentally-friendly features and practices incorporated in the projects. Points are given to projects that fulfill these criteria using environmentally-friendly features. Along with the overall assessment, the accumulation of points is then used to certify the project to one of the BCA Green Mark ratings. Unique to Singapore, previously certified Green Mark buildings are required to be re-evaluated every three years to maintain their status within the Green Mark criteria.

2.2 BEAM Plus

The BEAM scheme was launched in 1996 as a building environmental assessment method for Hong Kong, which uniquely assessed 'new buildings' and 'existing buildings' with separate criteria (BEAM Society, 2012b). By 1999, the BEAM scheme was updated to include a new assessment of high-rise buildings. In response to rising local issues, such as the SARS epidemic in 2003, and international problems such as global warming and

climate change, the BEAM scheme has seen many revisions as a response to a wide range of issues regarding sustainability and quality of buildings in Hong Kong. This project used data from assessment reports under the BEAM Plus scheme 1.1 (BEAM Society, 2010a; 2010b), launched in April 2010, and BEAM Plus scheme 1.2 (BEAM Society, 2012b; 2012c), launched on August 2012. At the time of writing this report, applicants must fulfill BEAM Plus v1.2 if they are certified after January 2013 (HKGBC, 2014).

2.2.1 The role of BEAM Plus

The BEAM rating tool, specific to Hong Kong, was created with the goal to "reduce the environmental impact of buildings using the best available techniques and within reasonable additional cost" (Yau, Lau, & Choi, 2014, p. 31). BEAM intends to assure that its certified buildings will embrace "hygiene, health, comfort, and amenity; land use, site impacts and transport; use of materials, recycling, and waste management; water quality, conservation and recycling; and energy efficiency, conservation and management" (BEAM Society, 2012b). BEAM's hope is to establish basic environmental standards for the entire city to comply with in order to benefit the health and livelihoods not just of its citizens but the general environment.

Combating Hong Kong's pollution and energy consumption problems through the certification of green buildings can help Hong Kong become a more environmentally friendly city. The air pollution levels in Hong Kong, at current levels, do not meet Air Quality Standards, in part because it is a regional problem in China, but also because emissions from vehicles and the building sector have not yet been stabilized (Environmental Protection Department, 2013). In Hong Kong about 60% of the city's

GHG are produced by buildings, which is about double the global average (Yau, Lau, & Choi, 2014). Similarly, 90% of electricity consumed each year in Hong Kong is from the building sector (BEAM Society, 2012b; The Government of Hong Kong Special Administrative Region, 2013b). The major source of this problem is related to the humid climate; during the hottest days, citizens will use their air conditioners the most due to poor insulation in the buildings (Government of Hong Kong Special Administrative Region, 2005). BEAM Plus has constructed its criteria to answer these issues through specifying a management of ventilation and airborne pollutants. These specific credits can be found in Appendices G & J.

BEAM Plus's standards are constantly being modified to respond to environmental problems to the best of its ability; the range of environmental foci has expanded vastly from its launch scheme (BEAM Society, 2012b). The perceived value of BEAM Plus has also risen as BEAM Plus has seen a recent boom in registered projects with an average of 150 new projects per year between 2011 and 2013, compared to an average of 16 projects per year in the years prior to that and since its original implementation (Yau, Lau, & Choi, 2014).

2.2.2 The Characteristics of BEAM

In order to promote BEAM Plus credits, it is necessary to include criteria that aim to solve problems caused by Hong Kong's unique environment and specific climate. BREEAM was the model for Hong Kong's BEAM, however many modifications have been made to BEAM to suit Hong Kong's unique climate (Lee and Burnett, 2008). Hong Kong has a warm, high-humidity, subtropical environment. However, it differs from other tropical countries in that it has four distinct seasons because of its location on the

southern edge of the continent of Asia (Yeung, Yuen, Dunn, & Cornish, 1992). The specific needs of Hong Kong are addressed in BEAM Plus' criteria, such as the proper location of domestic air-conditioning units.

The structure of Hong Kong's economy underwent a significant change in the 1980s and 1990s (Chan, 2008). The movement of labor-intensive manufacturing to southern China and away from Hong Kong, created a shift to a service-sector dominated economy in Hong Kong. Because of its service-based economy, Hong Kong is a high-density environment with many high-rise buildings.

Compared to the 56 credits in the 1996 version of the rating tool, there were 86 credits for high-rise residential schemes in 1999 (Yau, Lau, & Choi, 2014). Furthermore, there are many buildings that combine both commercial and residential sectors, and the weights are different for the commercial sector and residential sector while assessing one building. As for the commercial building sector, it is subjected to legislative control under the Building (Energy Efficiency) Regulation, which became effective on July 21, 1995. The legislative controls imposed minimum requirements on efficiency of air conditioning, lighting, electrical installations, and lifts and escalators in new buildings (Yik, Burnett, Jones, & Lee, 1998). Because the amount of carbon dioxide emissions, a major cause of global warming, is large in Hong Kong, greater efficiency of energy use, especially electricity, in buildings is a major focus for BEAM under the global issues section.

2.2.3 Credits

The BEAM Plus is driven by The BEAM Expert Panel formed in June 2012 (BEAM Society, 2012a). The BEAM Expert Panel includes five aspects: Site Aspects

(SA), Material Aspects (MA), Energy Use (EU), Water Use (WU), and Indoor Environmental Quality (IEQ), plus an Innovations and Additions (IA) Panel.

2.2.3.1 Description of credits

Acquiring credits is essential to earning BEAM Plus certification; each credit of BEAM Plus outlines a green building performance objective (BEAM Society, 2012b). Applicants for BEAM Plus during the certification process will submit documentation to BEAM Society Limited that indicates the credits they have applied for and the necessary supporting documents to substantiate their claims. If BEAM Plus practitioners determine that the credit was adhered to and successfully completed, a credit is awarded. These credits are generally guidelines to enhance green building performance, so the more credits awarded, the higher the projected positive environmental impact. This number of credits completed added to a total number of points awarded, which at the end of assessment determine the grade of the building, signaling the strength of the green building performance.

BEAM Plus divides credits into six distinct categories: Site Aspect (SA), Material Aspects (MA), Energy Use (EU), Water Use (WU), Indoor Environmental Quality (IEQ), and Innovations and Additions (IA) (BEAM Society, 2012b). Separating the criteria into categories is an effort to address a wide range of sustainability issues, as well as inform applicants where buildings need to improve for ‘greener’ performance (HKGBC, 2014). Site Aspects credits reflect how the building will impact the neighboring people and surrounding ecology. This includes assessment of the land the building will be built on and how transportation navigates to and from the building. Material Aspects concentrates on the types of materials used in construction, operation, and maintenance of the

building. The management of materials can reduce on site materials costs and reduce the waste generated throughout the lifetime of a building. Energy Use credits are awarded where a high standard of energy efficient technology is observed. Water Use credits, much like Energy Use, are concerned with the conservation of water to prevent wasteful activity and pollution. Indoor Environmental Quality is a broad grouping of credits designed to enhance the quality of life within buildings. These credits generally focus on lighting, noise, and air quality to create more livable environments. Finally, Innovations and Additions is BEAM Society's way to encourage designers to create new systems not outlined in the BEAM Plus criteria to promote green building performance. These credits are evaluated by the Board of Directors for approval and require investigation to award a credit.

The complete list and description of credits for New Buildings V.1.2 is in Appendix B, and Existing Buildings V.1.2 is in Appendix C. The lists for comparison of New Buildings between V.1.2 and V.1.1 are in Appendix D, and comparison of Existing Buildings between V.1.2 and V.1.1 are in Appendix E.

2.2.3.2 Weight/importance of credits

Once all of the BEAM Plus credits have been assessed, a final 'grade' is given, indicating the strength of the certification (BEAM Society, 2012b). The grade is determined by the percentage of credits completed within each category (certain credits are not applicable to all project sites and therefore removed from evaluation in grading), which are weighted differently upon final assessment.

Table 2.1: The BEAM Plus category weighting (BEAM, 2012b)

Category Weighting	(%)
Site Aspects (SA)	25

Materials Aspects (MA)	8
Energy Use (EU)	35
Water Use (WU)	12
Indoor Environmental Quality (IEQ)	20
Total	100

The following is a list of possible grades to earn after assessment of credits achieved:

Table 2.2: BEAM Plus minimum requirement for each rating category (BEAM, 2012b)

	Overall	SA	EU	IEQ	IA
Platinum	75%	70%	70%	70%	3 credits
Gold	65%	60%	60%	60%	2 credits
Silver	55%	50%	50%	50%	1 credit
Bronze	40%	40%	40%	40%	0 credits

As seen above, Site Aspect, Energy Use, and Indoor Environmental Quality are the only credit categories that demand a minimum percentage of credits completed to achieve a particular grade (BEAM Society, 2012b). There are a number of prerequisite credits that each building attempting to be BEAM Plus certified must complete, but outside of those credits, the percentage of credits completed depends on the developers' own choosing. These credits are outlined in Appendices B to E.

2.2.4 Process of Certification

The procedure for BEAM Plus certification is lengthy and at times rigorous. Registration forms, initial payments, acknowledgement letters, and submission of materials of the project site must be submitted to begin the assessment. Assessment is either a one or two-step process, depending on whether the applicant is using the assessment scheme for New Buildings or Existing Buildings. New Buildings require a Provisional Assessment and Final Assessment. A Provisional Assessment is a collection of templates and relevant materials for review and approval based on the sketched design

plans and current status of construction. The Final Assessment is also a collection of submissions of templates and relevant materials to show compliance but is performed after construction is completed. The benefit of the Provisional Assessment is to give the applicant the chance to improve building design during construction from feedback in the report. Existing Buildings have only a one step process, requiring only the Final Assessment at the end of construction.

2.3 Government Support

Hong Kong's government is highly committed to building a sustainable future that ensures its current and future residents will live in a cleaner, greener environment (Government of Hong Kong, 2014). The government is a strong believer in incorporating sustainability into the design and management of green buildings as it provides them with a resounding sense of achievement. This sense of approval is felt in Hong Kong's definition of green buildings: "[buildings] designed, built, renovated, operated, and reused in an ecological and resource-efficient manner" to impact a variety of objectives from keeping occupant health a priority, to using resources efficiently enough to reduce the impact on the environment (Para 2).

The Hong Kong government has set forward different types of schemes and recommendations to encourage building owners and construction companies to utilize sustainable design and management practices to promote the expansion of sustainable buildings (The Government of Hong Kong Special Administrative Region, 2014). The Considerate Contractor Site Award Scheme, organized by the Development Bureau in 1995, has served as a category of awards that promotes a good attitude for site safety and clean practices for public works and non-public works sites (Para 1). Under the 21st

Scheme, the categories for awards are as follows: Considerate Contractors Site Award, Outstanding Environmental Management and Performance Award, Model Worker Award and Best Model Worker Award, Model Frontline Supervisor Award and Best Frontline Supervisor Award, and Model Subcontractor Award. Each award category is then assessed using varying criteria. The Considerate Contractors Site Award is assessed in accordance with the following codes of practice: safety, law abiding, site management, environmental consciousness, being considerate to neighborhood and passers-by, care of workers and others, adoption of guidelines issued by the Construction Industry Council, innovativeness and creativity of safety measures.

Launched in 2001, the Green Contractor Award Scheme, under authority of the Architectural Services Department (2014), serves as an award system for contractors whose contracts obtained the highest scores in terms of environmental performance. The scheme, conducted annually, gives contractors the opportunity to show their sustainable and environmental performance on their construction site while aiming to improve their standards continually. Contractors that have taken the opportunity to do so have the chance to win the highest award possible, Gold. Following this award are Silver, Bronze, and Term Contract. With these two schemes in place the government expects to inspire contractors to take into account environmental aspects from the very beginning stages of building; taking a literal ground-up approach in creating augmented sustainable buildings in Hong Kong.

Under the recommendations from the Council for Sustainable Development, the government of Hong Kong (2014) reviewed a policy of allowing privately owned buildings to increase their floor space to incorporate green features. With the decision to

tighten the policy, steps have been taken to remove concessions for specific features. The government wants to lower the "level of concessions for car parks, balconies, utility platforms, and residents' recreational facilities" as well as imposing a maximum 10% for a number of features that still qualify for concessions. To obtain concessions the following prerequisites must be met: the "incorporation of sustainable design elements for building separation, setback and greenery in new buildings", and the "provision of environmental and energy consumptions information". With this amended policy, the government believes a balance between the fulfillment of comfortable environmental performance and reduction in the impact on the surrounding environment will be reached, thus allowing for a greener practice of building design while still leaving room for creativity.

As stated in the 2013 Policy Address by Hong Kong's Chief Executive, Mr. C Y Leung, Hong Kong had determined that nearly 90% of its electrical consumption and 60% of greenhouse gas emissions came from the building sector (The Government of Hong Kong Special Administrative Region, 2013b). To combat this high percentage, the Secretary of the Environment was asked to direct an inter-departmental committee to further promote the use of green buildings. The committee's goal is to strengthen the ties among private and public departments and bureaus to develop the implementation of strategies and schemes, while maintaining a level of collaboration between the sectors. The Steering Committee on the Promotion of Green Building, as of the 2014 Policy Address by Hong Kong's Chief Executive, Mr. C Y Leung, now considers the views of the industry and tries to learn from overseas experiences, while still committed to further

promoting green buildings and making recommendations to the measures associated with it (The Government of Hong Kong Special Administrative Region, 2014).

One of the government's major efforts, and its most specific one, involves the implementation of an Indoor Air Quality Management Program that aims to improve indoor air quality and promote the public's awareness of its importance (Government of Hong Kong, 2014). A voluntary, and free of charge, IAQ Certification Scheme for Offices and Public Places was set up by the program to have buildings awarded with either a "Good Class" or "Excellent Class" IAQ certificate that meets its two level objectives: Excellent Class and Good Class, as shown in Table 2.3 (The Government of the Hong Kong Special Administrative Region, 2003).

To make a site's achievements known to the public, IAQ labels are also distributed at the site location (The Government of Hong Kong Special Administrative Region, 2013a). With 70% of people spending their time indoors, IAQ has significant impacts not only on the health but comfort of the building's occupants. The government aims to recognize good IAQ management and provide incentives for building owners to follow through with the highest level of IAQ possible.

Table 2.3: IAQ Objectives for Offices and Public Places (The Government of the Hong Kong Special Administrative Region, 2003)

Parameter	Unit	8-hour average [a]	
		Excellent Class	Good Class
Room Temperature	°C	20 to < 25.5 [b]	< 25.5 [b]
Relative Humidity	%	40 to < 70 [c]	< 70
Air movement	m/s	< 0.2	< 0.3
Carbon Dioxide (CO_2)	ppmv	< 800 [d]	< 1,000 [e]
Carbon Monoxide (CO)	$\mu g/m^3$	< 2,000 [f]	< 10,000 [g]
	ppmv	< 1.7	< 8.7
Respirable Suspended Particulates (PM_{10})	$\mu g/m^3$	< 20 [f]	< 180 [h]
Nitrogen Dioxide (NO_2)	$\mu g/m^3$	< 40 [g]	< 150 [h]
	ppbv	< 21	< 80
Ozone (O_3)	$\mu g/m^3$	< 50 [f]	< 120 [g]
	ppbv	< 25	< 61
Formaldehyde (HCHO)	$\mu g/m^3$	< 30 [f]	< 100 [f, g]
	ppbv	< 24	< 81
Total Volatile Organic Compounds (TVOC)	$\mu g/m^3$	< 200 [f]	< 600 [f]
	ppbv	< 87	< 261
Radon (Rn)	Bq/m^3	< 150 [i]	< 200 [f]
Airborne Bacteria	cfu/m^3	< 500 [j, k]	< 1,000 [j, k]

2.4 Environmental Performance of Green Certified Buildings

The true environmental performance of green certified buildings has been somewhat in question over the past several years (Scofield, 2013). For example, LEED has received complaints that the certification tool allows for non-environmentally friendly buildings to receive green certification. Research has been done in order to better understand the performance of green buildings.

2.4.1 Energy Savings

Energy consumption is an important factor to consider when assessing green buildings as the production of energy contributes to pollution in a major way. A study conducted by the New Building Institute compares the Energy Use Intensities (EUI) data

of 121 LEED certified buildings to the data for the national building stock provided by the Commercial Building Energy Consumption Survey (CBECS) (Turner & Frankel, 2008). This study found that "the median measured EUI was 69 kBtu/sf, 24% below (better than) the CBECS national average for all commercial building stock". As clearly shown in this study, green buildings on average use significantly less energy than their non-green counterparts.

2.4.2 Occupant Satisfaction in LEED and non-LEED Certified Buildings

LEED is very similar to BEAM Plus in that both green building rating tools have credits about Indoor Environmental Quality (IEQ) (US Green Building Council, 2012; BEAM, 2012b). For example, LEED requires all certified buildings to meet the credit, Minimum Indoor Air Quality Performance (US Green Building Council, 2012). Beam Plus for New Buildings V.1.2 has a vast number of credits under the category of IEQ, and to receive a Bronze rating a building must achieve at least 40% of the credits from this category (BEAM, 2012c). Studies about occupant satisfaction of IEQ, the building, and the workspace have been carried out comparing LEED and non-LEED certified buildings with the purpose of determining if there is increased, neutral, or decreased occupant satisfaction about IEQ in LEED certified buildings over non-LEED certified buildings (Altomonte & Schiavon, 2013). A report, published by the Center for the Built Environment (2013), shows that LEED certification doesn't have a significant influence on occupant satisfaction of IEQ, the building, or the workplace, as shown in Table 2.4. Overall, the study showed that occupants of LEED and non-LEED certified buildings were equally satisfied with the building and workplace overall. There are a few IEQ categories that were evaluated in which occupants were more satisfied in one building

type over the other. The mean occupant satisfaction of the amount of light in LEED certified buildings was lower than for non-LEED certified buildings, while the mean occupant satisfaction of air quality in LEED certified buildings was higher than non-LEED certified buildings.

Table 2.4: Mean Occupant Satisfaction of LEED v.s. non-LEED certified buildings on a scale of -3 (very dissatisfied) to 3 (very satisfied) (Altomonte & Schiavon, 2013)

	LEED	non-LEED
Building	1.08	1.07
Workspace	0.95	0.87
Amount of Light	0.92	1.33
Air Quality	0.80	0.40

2.4.3 Financial Benefits of Going Green

Building environmental assessment tools are designed to be cost management tools by guiding the construction of buildings to implement cost efficient features that will reduce total costs over the full lifecycle of the building (BEAM Society, 2012a). The theory is that going green will benefit firms through greater economic return, reduced litigation and financial risk, enhanced brand publicity, broader sense of payback, and advantage of early entry into a new market (Cui, Le & Lu, 2013). Initial studies have shown that investment in environmental performance and management can correlate with good financial practices and benefits. While the construction of green buildings typically presents higher costs upfront, statistical analysis (ROE, ROC, Tobin's Q, EVA margin, P/E, EV/EBITDA) shows the financial short term and long term financial performance of green firms outperform their comparative conventional firms counterparts. Recent studies need to account for the economic downturn from 2007 onwards, but those studies have

shown that while green firms are more sensitive to economic changes, their financial performance in that period was stronger than their conventional counterparts. Despite clear financial benefits, investors typically have shown no preference for green over non-green firms.

2.5 Barriers Preventing Buildings from Becoming Green

There are a variety of barriers that prevent buildings from becoming green. Many of these barriers are caused by the public's general lack of knowledge about green buildings (Hoffman & Henn, 2008).

2.5.1 Public Perceptions and Misconceptions

There are many factors that prevent new and old construction from becoming green certified, and a large number of these factors are caused by public misconceptions and opinions (Hoffman & Henn, 2008). Ranging from the owner to the architect to the construction workers, these are only some of the people involved in the green building design and construction process, and the misconceptions and opinions of each of these categories of individuals can negatively impact the resulting success of the green building. Some people view the term "green building" with a negative connotation as they assume that sacrifices, such as low water pressure, will have to be made inside the building to achieve a green standard. This negative view by anyone involved in the process could prevent any further thought of building a green building. Others assume that green buildings are very expensive compared to non-green buildings. A study conducted by the World Business Council on Sustainable Development (2007) showed that on average a person will overestimate the upfront price of a green building by 17% when in reality the average green building is only 6% more expensive than its non-green

counterpart. Were the owner of a building to have this over-priced misconception, they may rule out the idea of building a green building strictly based on financial considerations. Clearly, there is a lack of knowledge in the general public about green buildings, and unless changes are made, situations such as those mentioned above will continue to prevent green buildings from being built.

While there is plenty of discussion of building environmental assessment methods, there is not enough assessment of actual building performance data, especially for BEAM Plus certified buildings in Hong Kong. Also, there is not yet a measure of how BEAM Plus is creating a social impact, whether it's with building managers valuing sustainability more since the establishment of BEAM Plus, or with occupants adapting to their homes or their workplaces. Our project plans to fill this research gap.

3. Methodology

The goal of this project is to suggest modifications to credits within the BEAM Plus rating tool to stimulate improvement in sustainability standards of buildings in Hong Kong.

Our measurable objectives were:

1. Identify the strengths and weaknesses of the BEAM Plus scheme.
2. Determine how BEAM Plus certified buildings have implemented the installed green technologies outlined in the achieved credits.
3. Determine occupants' perceptions of and satisfaction with green buildings.

We used archival research, case studies, occupant surveys, and statistical analysis to achieve our objectives, which we discuss in detail in this chapter.

3.1 Identify the Strengths and Weaknesses of the BEAM Plus Scheme

The first phase of our project was to conduct archival research by reviewing 110 previously analyzed assessed project reports and 106 new project reports assessed in 2014 to identify trends related to which credits were achieved and how. Each assessment report includes a summary of the project site's sustainable features at the time of assessment, and the status (Not Applicable, Not Submitted, Number of Achieved, and Not Achieved) of each BEAM Plus credit. We determined the strengths and weaknesses of the BEAM Plus Rating System by analyzing all the data found in provisional and final assessment reports and reviewed the achievability of credits to understand the obstacles during certification. We then evaluated how successfully BEAM Plus credits challenge

buildings toward an improved sustainability standard. Our archival research was divided into 4 tasks.

3.1.1 Task 1: Analyze New Provisional and Final Assessment Reports

The first part of the archival research was the data acquisition of individual credit statuses found in Final and Provisional Assessment reports. The status of the credits from the Credit Summary section of each report was recorded in an Excel spreadsheet. The 216 reports were sorted by their respective BEAM Plus ratings, i.e. Unclassified, Bronze, Silver, Gold, and Platinum. Additional information was incorporated to facilitate the use of the file such as building type. The team then carried out a statistical analysis by calculating the full achievement rate of the inputted data to determine trends of both frequently achieved and infrequently achieved credits. We then calculated the differences in full achievement rates of credits between Platinum and all other building grades. The data were then presented using various visual techniques, such as graphs and tables, to represent our findings.

3.1.2 Task 2: Analyze Not Submitted Credits and BEAM Plus V1.2 Projects

Part of this task was to catalog credits applicants did not apply. Our team summarized "Not Submitted" credits for all 216 assessed reports in an Excel spreadsheet and then calculated the "Not Submitted" rates for each credit. We analyzed the difficulties and challenges of fulfilling these credits by consulting credit descriptions, contested credit reasons, and online sources. This analysis helped us make suggestions on how to reduce the number of not submitted credits.

An analysis of Existing Buildings scheme was also conducted by cataloguing the credit statuses for the 5 Existing Buildings assessment reports in an Excel spreadsheet. The achievement rates, not submitted rates, and contested rates of the Existing Buildings credits were calculated to identify any trends found in this unique, but small, category.

The other part was to analyze the achievability of credits that differed in V.1.2 (EU1 and IEQ15, see Appendix C). We also recorded the status of each credit for all V.1.2 projects and focused on qualitative analysis of sub-credits under EU1 and IEQ15, in order to measure how successful the revised credits were to improve achievement rates of BEAM Plus V.1.2 credits.

3.1.3 Task 3: Analyze Conversion Projects

This task aimed to understand why conversion projects never received a rating higher than Bronze. For this task, the team recorded credit status data from all of the BEAM Plus certified conversion projects into an Excel spreadsheet. Of the 10 Unclassified projects and 6 Bronze projects, only Bronze projects were studied, as the Unclassified projects would skew the data because they only applied for credits in Energy Use and Indoor Environmental Quality to meet a Building Department requirement. Any credit that either failed or was Not Applicable for 80% or more of the projects was recorded. Using the recorded credits, more analysis was conducted to determine which of these credits were unattainable for conversion projects. The unattainable credits were compiled in a document with specific explanations demonstrating why the credits should not comply with conversion projects. We recalculated the scores of the 6 Bronze conversion projects by changing the status of these unattainable credits to Not Applicable.

3.1.4 Task 4: Qualitative Analysis of Projects and Contested Credits

Learning the context of how credits are earned was necessary for us to make suggestions to improve the pursuit of credits. The objective of this task was to analyze any qualitative and quantitative information found in the Credit Summary section of the provisional and final assessment reports. Each project was required to submit the methods, accomplishments, and measurements to be considered for any credit. The list of claims is summarized in the assessment reports. The WPI research team, who worked with HKGBC in 2014, created Excel spreadsheets (grouped by BEAM Plus grades) that listed quantitative data about energy savings, water savings, and green technologies implemented. We added the 106 projects evaluated from 2014 to these Excel spreadsheets, following the established format. We also added the innovative accomplishments (innovations fall under credits IA1 and IA2, see Appendix B) for all 216 projects to these spreadsheets. Finally, we added another section to these spreadsheets that listed all the reasons credits were contested.

Using all of the above analyses, our group determined strengths and weaknesses of BEAM Plus, which was helpful in formulating our recommendations about how to modify BEAM criteria for a stronger, positive environmental impact.

3.2 Determine Usages of Green Technologies in Existing Certified Buildings

To determine the implementation of green technologies in certified buildings, we carried out case studies of Platinum certified buildings. Our project team went on public

tours of two Platinum buildings, conducted three interviews of building managers, and surveyed occupants of two Platinum certified universities.

3.2.1 Public Tours

We attended two public tours of Platinum buildings to explore their state-of-the-art ecologically friendly buildings. We completed reports of our observations about the implementation of green technologies, the occupants' behavior, and our own impressions of the indoor environmental quality. Photographic data was collected to help represent our findings and showcase the innovations used by each building. These tours also provided our team with more background information with the final edits to our occupant surveys.

3.2.2 Interviews with Building Managers

Our team conducted interviews with the building managers of three BEAM Plus Platinum certified buildings. Building C, an estate of high technology industries, built in 2012, was certified to New Buildings. Building D, an aged public estate, and Building E, a low-rise office building, were both certified to BEAM Plus Existing Buildings. We designed separate interview protocols, with input from our sponsor, for each of the three interviews. The intent was to learn about the unique tasks associated with maintaining BEAM Plus certified buildings and learn about challenges the facility teams are faced with when maintaining these technologies. These interviews also helped us identify the differences in maintaining certified existing and new buildings. The interview protocols are in Appendix P, Q & R.

3.2.3 Observations of Surveyed Sites

The overall efficiency of BEAM Plus certified buildings was analyzed through our observations of site conditions. These case studies were conducted in two Platinum certified universities.

Before going to each building, we highlighted their significant accomplishments as stated from the Assessment Reports for significant features to observe. Observing the implementation of green features, such as tap infrared sensors and green roofs, was essential for us to understand the differences between actual site practices and simulated practices. Our scopes of observations were wide, ranging from temperature, air quality, energy usage, and occupant behavior. Visual observations augmented our understanding of how buildings have successfully, or unsuccessfully, followed their BEAM Plus certified design plans.

3.3 Determine occupants' perceptions and satisfaction

In order to determine occupants' perceptions and satisfaction of green buildings, we surveyed occupants of two Platinum certified buildings. We distributed 100 questionnaires to occupants in each of the universities. Our intent was to gain an understanding of the occupants' knowledge about green buildings and determine the occupants' level of satisfaction with the performance of the building, the indoor environment, and technologies used in the buildings. The questionnaire distributed to the occupants is in Appendix S.

3.4 Summary

The methods described above were used to fulfill our goal: to suggest modifications to the BEAM Plus scheme to stimulate improvements in sustainability standards in Hong Kong buildings. The archival data analysis helped us to understand the challenges faced when applying for credits. The case studies assessed how Platinum buildings are maintained and studied occupants' perceptions and satisfaction with green buildings. Our statistical analyses and case studies of Platinum certified buildings enabled us to suggest modifications to the Hong Kong Green Building Council on how to improve BEAM Plus credits to be more suitable for Hong Kong's specific environment.

4. Results and Analysis

In this chapter, we discussed results and analysis of the archival research and data analysis of 210 projects, public tours, interviews with building managers, and occupants' surveys. We identified the strengths and weaknesses of the BEAM Plus scheme, determined how green features are currently maintained and their cost-effectiveness, and learned about occupants' perceptions of and satisfaction with green buildings. Based on our research, we successfully achieved our goal to suggest modifications for our sponsor, HKGBC, to stimulate improvement in sustainability standards of buildings in Hong Kong.

4.1 The strengths and weaknesses of BEAM Plus

To identify the strengths and weaknesses of the BEAM Plus scheme, we studied outstandingly accomplished standards and currently infeasible standards for buildings in Hong Kong. The results from our archival research are divided into the sections we outlined in our methodology: there is a full analysis of achievement rates of all projects, of not submitted credits, of certified existing buildings, of BEAM Plus V.1.2 buildings, of conversion projects, of a catalogue of green features, and of contested credits.

4.1.1 Achievement rates of BEAM Plus Credits

We analyzed achievement rates for all credits of new building projects to identify prominently high-achieved and low-achieved credits.

We started with an analysis of the 100 projects from 2014. The top ten and bottom ten credits in terms of achievement rates were calculated to determine which credits were easily achieved compared to credits with lower achievability rates.

We performed the same analysis as above for 110 projects pre-2014. This was completed to determine the achievement rates of credits from previous years and to see if any changes in achievement rates had occurred. We observed no significant changes in the achievement rates of the credits respective to time. A record of the combined achievement rates of the credits from the 210 total projects spanning multiple years is listed in Table 4.1. A bar chart showing the achievement rates for all credits is in Appendix F.

Table 4.1: Top Ten Achieved Credits – All Consolidated

Credits Description	**% of Projects**
IA3 – BEAM Professional	85.71%
EU11a – Operations and Maintenance – Operations and Maintenance Manual	80.48%
EU10c – Testing and Commissioning – Ensure Full Commissioning	80.00%
EU10d – Testing and Commissioning – Commissioning Report	80.00%
EU10a – Testing and Commissioning – Commissioning Specification	79.05%
EU11b – Operations and Maintenance – Energy Management Manual	78.47%
SA10 – Environmental Management Plan	77.14%
EU10b – Testing and Commissioning – Commissioning Plan	75.71%
SA11 – Air Pollution During Construction	74.76%
MA8a – Ozone Depleting Substances – Refrigerants	76.64%

Table 4.2: Bottom Ten Achieved Credits – All Consolidated

Credits Description	**% of Projects**
MA7c - Recycled Materials – Interior Components	3.81%
EU6 – Renewable Energy Systems	3.81%
MA1B – Building Reuse (Bonus)	3.50%
IEQ19B – Noise Isolation (Bonus)	3.35%
WU2 – Monitoring and Control	3.33%
WU4b – Water Recycling – Recycled Water	3.33%
EU13 – Energy Efficient Building Layout	2.46%
SA8b – Microclimate Around Buildings – Elevated Temperatures	1.90%
SA1 – Contaminated Land	0.50%
MA5 – Rapidly Renewable Materials	0.00%

Credits referring to plans and manuals, such as operational, management, environmental, and commission, tend to have the higher achievement rates, with the Testing and Commission credits averagely marking an 78.64% achievement rate. On the other hand, credits that encourage the application of environmentally friendly and sustainable features, such as use of recycled materials and renewable energy systems, are rarely achieved. Building reuse is also a low adherence credit, perhaps due to the potential gain in property value if a building is rebuilt rather than retained. For recycled materials in interior components, low achievability is likely due to an absence in available products, the designer's tendency to adopt high-quality products in order to safeguard property values or achieve design intent, or unclear definition of recycled materials in the BEAM Plus scheme.

We focused on the credit SA8b, a strong green feature (lowers the solar heat gain around the building), and has a very low achievement rate. From Table 4.1, SA8b, Microclimate Around Buildings - Elevated Temperatures only has an achievement rate of 1.90%, with only 4 out of 210 projects attaining the full score of 2 credits. Credit SA8b gives one credit to a building site for providing canopy shading for over 50% of non-roof impervious surfaces on the site, such as walkways or plazas, by using high albedo materials with a minimum reflectance level of 0.3. A second credit is required to provide high emissivity roofing, with an emissivity of 0.9, or provide vegetation roofing covering 50% of the total roof. The majority of buildings achieved the SA8b credit concerning vegetation roofing or high emissivity roofing materials more frequently: approximately 57.6% of projects achieved the credit about high emissivity and vegetation roofing, but only 2.4% achieved the canopy shading credit.

Figure 4.1 serves to show the top 10 highest differences in achievement rates between all projects and Platinum projects, and differences descend from left to right.

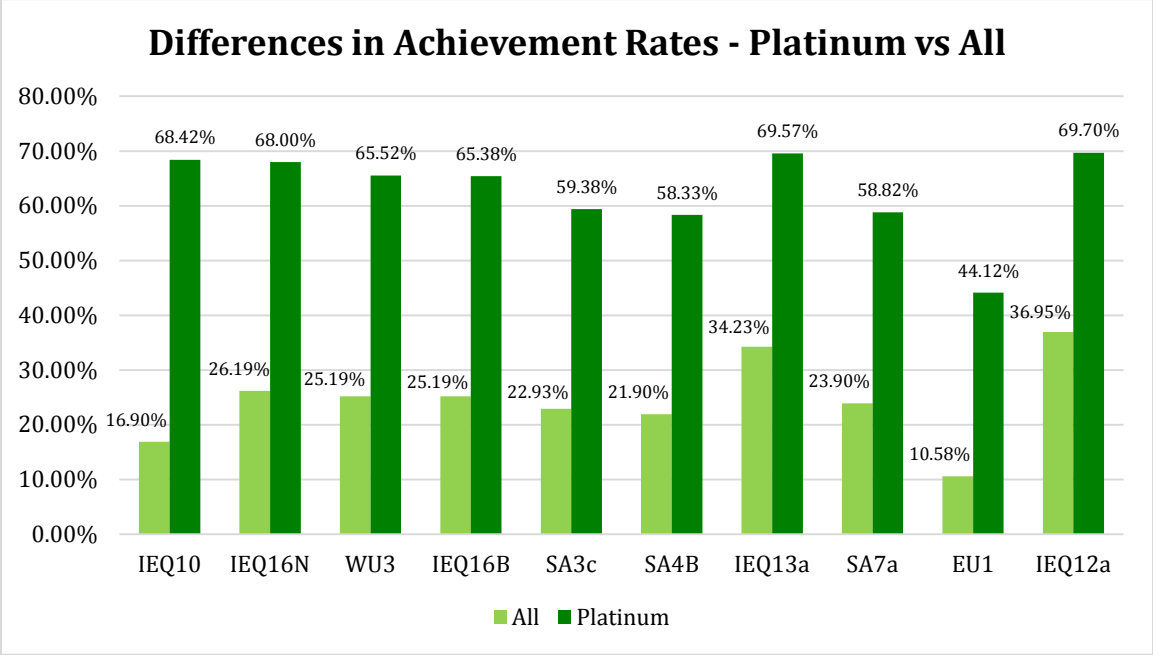


Figure 4.1: Difference in Achievement Rates of Platinum Projects vs. All Projects

Our analysis shows that 5 out of the 10 credits with the largest difference in achievement rates between Platinum and All Projects are Indoor Environmental Quality credits, which appear to have the highest difference in implementation between All projects and Platinum projects. The bar chart showing the difference between Platinum and all projects for all credits is in Appendix G.

4.1.2 Not Submitted Credits

To identify some infeasible credits, we summarized the information for the Not Submitted credits from all 210 assessed projects, and sorted the Not Submitted credits for all projects and platinum projects in descending order. A bar chart showing the percentage of all and platinum projects is in Appendix H. Table 4.3 and Table 4.4 show

the 10 most commonly not submitted credits of all projects and Platinum projects respectively. We used these tables to identify the common weaknesses of BEAM Plus.

Table 4.3: 10 Most Common Not Submitted Credits (All projects)

Credits Description	% of projects
MA5 - Rapidly Renewable Materials	98.6%
MA7c - Interior Building Component	96.2%
WU4b - Recycled Water	94.8%
MA3 - Prefabrication	93.3%
SA1(B) - Contaminated Land	92.9%
IEQ12b - Use of Natural Ventilation	86.7%
WU4c - A Combination	86.2%
MA7b - Building Structure	84.8%
WU2 - Monitoring and Control	84.8%
WU4a - Harvested Rainwater	83.8%

Table 4.4: 10 Most Common Not Submitted Credits (Platinum projects)

Credits Description	% of projects
MA5 - Rapidly Renewable Materials	97.0%
SA1(B) - Contaminated Land	90.9%
WU4b - Recycled Water	87.9%
MA7c - Interior Building Component	84.8%
MA7b - Building Structure	75.8%
MA3 - Prefabrication	75.8%
EU3(B) - Low Embodied Energy	69.7%
WU2 - Monitoring and Control	66.7%
IEQ12b - Use of Natural Ventilation	63.6%
WU4c - A Combination	60.6%

The majority of the 10 most frequently not submitted credits for all projects and platinum projects are the same, except the credit WU4a (Harvesting Rainwater), which is a frequently Not Submitted credit for all projects. For the same credits, the Not Submitted rate of Platinum projects is lower than the rate for all projects. This suggests that this credit is not infeasible, but is very hard to attempt. Thus, we focused on analyzing these overlapping credits.

The achievement rate of MA5, shown in Table 4.2, is 0%, and the not submitted rates of MA5 for both platinum projects and all projects are the highest rate out of all the credits in the BEAM Plus scheme. Therefore, we assume the feasibility of achieving MA5 is not likely in Hong Kong. Credit MA5 requires the use of rapidly renewable materials, which are natural and non-petroleum materials with harvest cycles of less than 10 years, such as bamboo, wool and wheat board. If 2.5% of the building material's or product's costs are for rapidly renewable materials, the building can receive 1 credit. If a building spends 5% of all costs on rapidly renewable materials, it can achieve 2 credits. Only 2 out of 210 projects received a score of 1 for this credit, and none of the projects achieved a score of 2 for this credit. To achieve 1 score, one Bronze project installed a bamboo panel, which cost 2.5% of all building materials, and one Gold project spent 4.8% of all the building materials cost on bamboo flooring and skirting.

Credit MA7c requires that at least 10% of all building materials used for interior non-structural components are recycled materials. The rest of the Material Aspect credits are listed in Tables 4.3 and 4.4 and require buildings to use 10% to 20% recycled materials. We analyzed that many of these credits have the same Not Submitted rate issues that credit MA5 encounters. Additionally, the definition of recycled materials is not clear in BEAM Plus scheme, which may lead applicants spend money on wrong materials.

We observed in some buildings, which only applied rapidly renewable materials for decorative purposes and recycled materials in exterior paving, that none of the high-rise buildings were able to reach the required percentages needed to receive a credit. Rapidly renewable materials are combustible and have limited structural strengths, and

receiving a credit depends on the percentages of spending on all materials. Recycled materials in interior components may affect the appearance of the materials, and as a result it may not be acceptable to designers and users. Hence, these credits are generally very difficult to achieve for most high-rise buildings in Hong Kong, and many applicants just choose not to submit for them.

There are four most commonly not submitted credits from Water Use. One is about water leakage monitoring and the others are about recycling water to reduce the consumption of fresh water. The total amount of water usage in high-rise buildings is considerably high, especially in residential buildings, which is the major category of BEAM Plus certified buildings. While some Hong Kong buildings already implement seawater flushing, there are limited venues where recycled water can find application, except irrigation and cleansing. This is one possible reason why the credits were not attempted.

Many buildings consist of more than one block with multiple functions. For example, some buildings are broken into two blocks, the residential area and the office area. If the residential area is 95% of total construction areas, applicants choose not to submit for the office block that is only worth a small amount of the total construction area, even if they applied the same technologies or green features to both blocks. Since preparing application documents is complicated and the weighting of each block depends on its percentage of the total construction area, not submitting for the office block usually does not influence the overall score for that credit.

4.1.3 Existing Building Analysis

There are five existing building projects certified with BEAM Plus, and we recorded the status of the credits (Not Applicable, Not Submitted, Failed, and the Number of Credits Achieved) to analyze the feasibility of all credits for existing buildings. The bar charts showing the contested rate, not submitted rate, and achievement rate for all credits are in Appendix I, J & K, respectively. The existing buildings were built 10 to 40 years ago, and recently became interested in green certification. We determined this earlier construction caused some credits to be infeasible for them.

Table 4.5: 100% Not Submitted Credits

Credits Description
MA2 – Modular and Standardized Design
MA4 – Rapidly Renewable Materials
MA5 – Sustainable Forest Products
WU2 – Monitoring and Control
WU4 (B) – Water recycling

Of the 100% not submitted credits (Table 4.5), three credits are from Material Aspects and two credits are from Water Use. These credits relate to features that need to be implemented during the construction of the building. For example, some Material Aspect credits require using certain types of materials in the structure, and Water Use credits require the installation of certain irrigation system or design recycling systems. Since existing buildings often have spatial and budgetary constraints, it is difficult for these features to be included in their designs.

4.1.4 V.1.2 Projects Analysis

We summarized the status and qualitative information of each credit for all V.1.2 projects by focusing on two heavily revised credits in V.1.2, EU1 and IEQ15. We analyzed how these revisions helped more buildings achieve higher levels of

certifications and how changing standards in BEAM Plus affected achievement rates, which helped us make suggestions improve the BEAM Plus scheme.

To satisfy EU1 (Reduction of Energy Consumption), information about a building's annual energy consumption plan must be provided. There is an alternative option in V.1.2, which is equivalent to EU1, EU2 (Peak Electricity Demand Reduction), and EU13 (Energy Efficient Building Layout) in V.1.1. EU1 Option 2 in V.1.2 asks applicants to submit five passive designs for site planning, building envelope, natural ventilation, daylighting and active building systems rather than the information about energy reduction. 10 out of the 46 V.1.2 projects chose EU1-Op2. The average number of achieved credits for the sum of EU1, EU2 and EU13 is 7.4 (out of 20) for 36 V.1.2 projects (out of 46) that chose Op1. The average number of achieved credits for EU1-Op2 is 14 (out of 20) for 10 V.1.2 projects. This shows that the achievability of this credit has significantly increased. Therefore, the implementation of EU1-Op2 has proven to be a good change helping applicants to reach higher grades. If we had more V.1.2 projects that applied for Option 2, we could form a stronger conclusion about this credit.

Figure 4.2 shows the achievement rates for the EU1-Op2 sub-credits for the 10 buildings that choose option 2. The achievement rates for all sub-credits, except natural ventilation, of EU1-Op2 are high and attainable by most projects. The EU1c-Op2 credit dealing with natural ventilation has never been fully achieved. The average number of achieved credits for natural ventilation is 1 credit (out of 5) for the prescriptive approach (8 out of 10 projects) and 2 credits (out of 5) for the performance approach (1 out of 10 projects). One project did not submit for this subcredit at all. The prescriptive approach requires some number of habitable areas to meet the ventilation requirements (open

windows), and the performance approach requires some number of habitable areas to satisfy the Area-Weighted Average Wind Velocity requirement. The feasibility of achieving this credit is not high in Hong Kong.

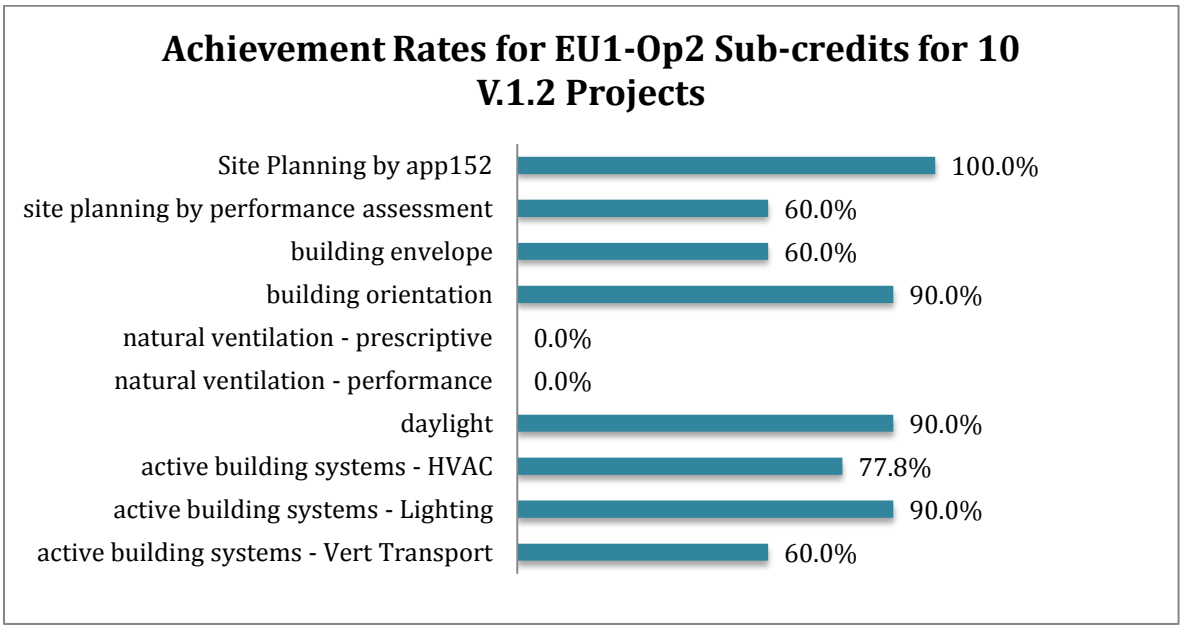


Figure 4.2: Achievement Rates for EU1-Op2 Sub-credits for 10 Buildings

IEQ15 is about daylighting. In V.1.1, the required daylight factor is 2% for at least 80% of the floor area, but the value of the daylight factor is relaxed to 1% in V.1.2. By reducing this factor, the full achievement rate (2 credits) of IEQ15 has increased. Figure 4.3 shows that nearly half of residential buildings were able to fulfill IEQ15 under V.1.2.

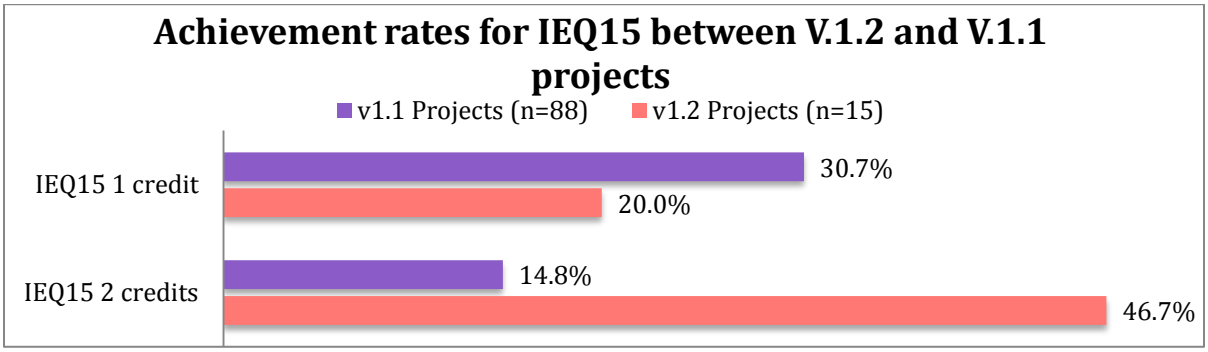


Figure 4.3: Achievement rates for IEQ15 between V.1.2 and V.1.1 projects

4.1.5 Conversion Projects

We analyzed sixteen conversion projects to determine why no conversion projects had received a BEAM Plus rating higher than Bronze. Out of the sixteen conversion projects we examined, 10 of the projects received an Unclassified rating, and 6 of the projects received a Bronze rating. Since most of Unclassified projects only aimed to get a score of 40% for both the Energy Use and Indoor Environmental Quality sections due to the Building Department's Requirements, these projects were not included in the credit analysis, and we only analyzed the Bronze projects.

To determine which credits were unsuitable for conversion projects, the achievement rates of credits for the 6 Bronze projects were calculated, along with the not submitted credits and the number of contested credits. This allowed us more easily to identify the particularly difficult credits to achieve for conversion projects. If there was a credit that was either not achieved or not submitted by over 25% of the projects, we analyzed why this might be the case. A bar chart showing these data about contested credits, achievement rates, and not submitted rates are in Appendices J, K and L respectively. From this analysis we were able to pick out the most important credits to study.

After analyzing each individual credit that the 6 Bronze projects applied for, we determined that there are some credits in the BEAM Plus scheme that are inappropriate for conversion projects. For example, credit MA3 requires the use of 20% prefabricated materials inside the building. These materials most commonly would be used in the structural elements of a building. During the construction phase of a conversion project , most of structural components of a building do not change, so we concluded that this is a

credit that should be Not Applicable to conversion projects. A full list of the 11 unsuitable credits for conversion projects is in Appendix O with reasons why the credits being unsuitable.

Table 4.6: Full list of the 11 unsuitable credits for conversion projects

Credit:	Description:
SA1 (B)	Contaminated Land
SA4	Site Design Appraisal
SA8a	Wind Amplification
SA8c	Air Ventilation Assessment
SA9	Neighborhood Daylight Access
MA2	Modular and Standardized Design
MA3	Prefabrication
MA4c	Structural Adaptability
MA6	Sustainable Forest Products
MA7	Recycled Materials
EU13	Energy Efficient Building Layout

Concluding our analysis of conversion projects, we re-calculated the rating that each of the six Bronze conversion projects would have received had these 12 credits been Not Applicable. Four of the Bronze projects got closer to achieving a Silver rating, but still received a Bronze rating. However, two of the projects received a Silver rating by using this new credit rating system.

4.1.6 Qualitative Analysis for All New Building Projects

We successfully appended the list of green features and energy savings from the 100 BEAM Plus New Buildings assessment reports from 2014 to the current catalogue of green features. The following is an analysis of the aggregate annual savings in water consumption (WUP2 and WU1) and of the annual reduction in CO2 emissions (EU1). We investigated into these credits because they reflect how BEAM Plus buildings directly, and how effectively, address the environmental problems of water and energy consumption in Hong Kong.

All projects need to show at least 10% aggregate annual water savings in WU P2 to be complete the BEAM Plus certification, but projects can receive WU1 credits that count towards their BEAM Plus grade if the buildings achieve over 20% water savings under WU 1. BEAM Plus projects can receive one WU1 credit for demonstrating 20% water savings, two for 25% and three for 30%. The savings in water consumption are compared to baseline assumptions of buildings, such as assumptions about water usage of occupants in building and flow rate from sinks. All projects had some water savings to report, even the Unclassified. The following are box charts comparing the distributions of annual water savings figures across all building grades. We use 10th percentiles, 1st quartiles (Q1), medians (Q2), 3rd quartiles (Q3), minimums, and maximums to show distribution.

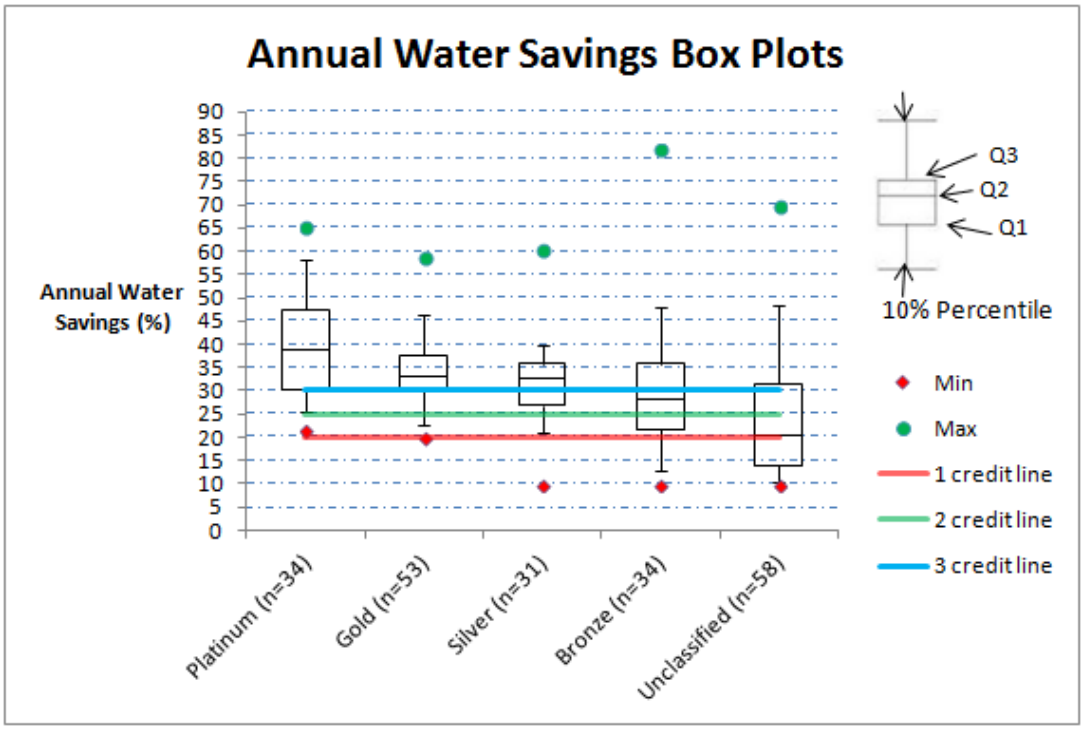


Figure 4.4: Box Plot of BEAM Plus grades

At least 75% of Platinum and Gold BEAM Plus certified buildings acquire over 30% water savings. Even 70% of Silver BEAM Plus buildings also attained over 30%

water savings. The majority of Bronze buildings also earned at least 20% water savings, with 44.1% achieving at least 30% water savings.

Unclassified buildings are unique because, while virtually all other projects submit for WU1 to receive credit, 79% did not submit for WU1. As shown in the box plot, despite these projects only aiming to satisfy 10% savings, there is a wide distribution of water savings. To show the wide distributions of the water savings data in Unclassified buildings, we instead analyzed the Unclassified data through a histogram that counts the number of buildings that fell between different ranges of savings in water consumption (for example, how many projects fell between 10-13% water savings versus 22-25%).

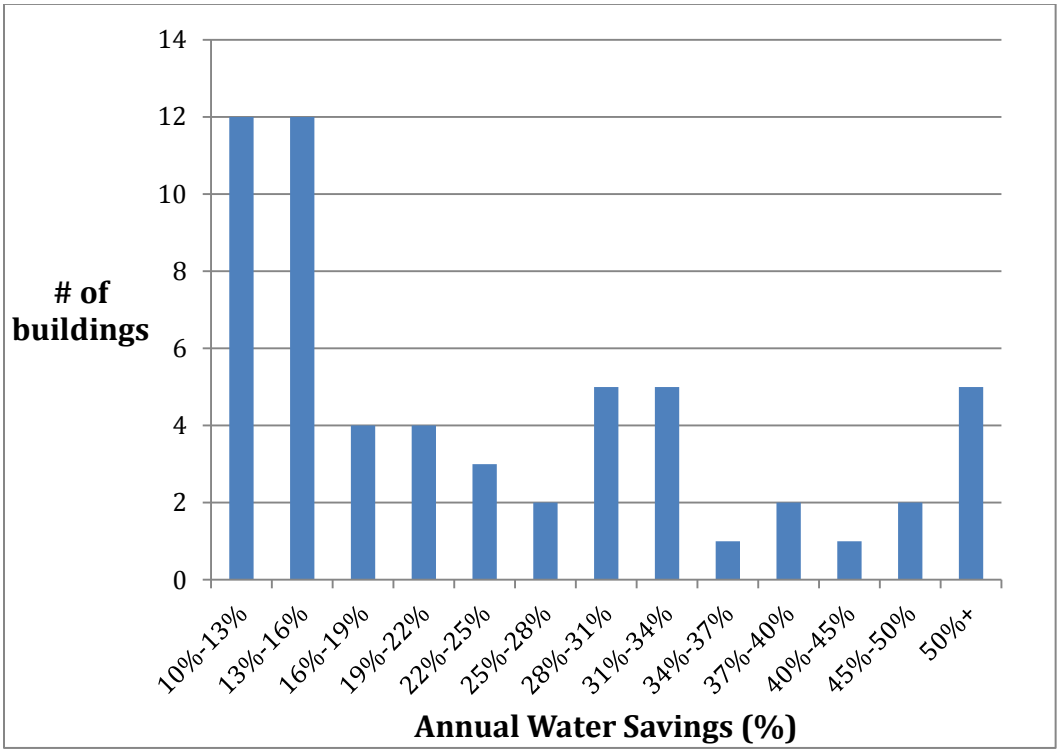


Figure 4.5: Histogram of Unclassified Buildings by Water saving

As shown in the histogram, nearly half of all Unclassified projects are clustered around the 10% savings, all that is needed to fulfill the prerequisite. However, the other

half of Unclassified projects achieve more than 20% water savings, with nearly 30% of Unclassified projects attain more than 30% annual water savings. Of the 17 projects that achieve more than 30% annual water savings, only 8 submitted to achieve those credits. Similarly, of the remaining 12 Unclassified projects that could have received some water usage credits for at least 20% annual water savings), only four actually did.

Across the majority of these projects, their achievement of reducing their projected water consumption can be attributed only to low flow sanitary fittings, not other methods like water recycling or rainwater harvesting.

Projects can receive up to 15 Energy Usage credits for demonstrating a quantifiable reduction in CO2 Emissions in EU1 alone. The percent reduction of CO2 emissions is compared to a baseline building of identical dimensions of size and whose energy performance barely meets the relevant regulatory requirements or meets only 'basic' design quality. The following are box plots of the distribution of Reduction of CO2 Emission across different BEAM Plus grades, separated between Residential and Commercial buildings. Residential and Commercial buildings are the most common building type in BEAM Plus, and were the only buildings type included in this analysis. Other buildings "other" and "educational" were excluded from analysis because of small sample sizes. In the BEAM Plus scheme, Commercial and Residential buildings must show reductions on different scales (to receive 15 EU1 Commercial buildings need to show at least 45% reduction and Residential only 20%) because of different assumptions about annual electricity demands. We use 10th percentiles, 1st quartiles (Q1), medians (Q2), 3rd quartiles (Q3), minimums, and maximums to show distribution.

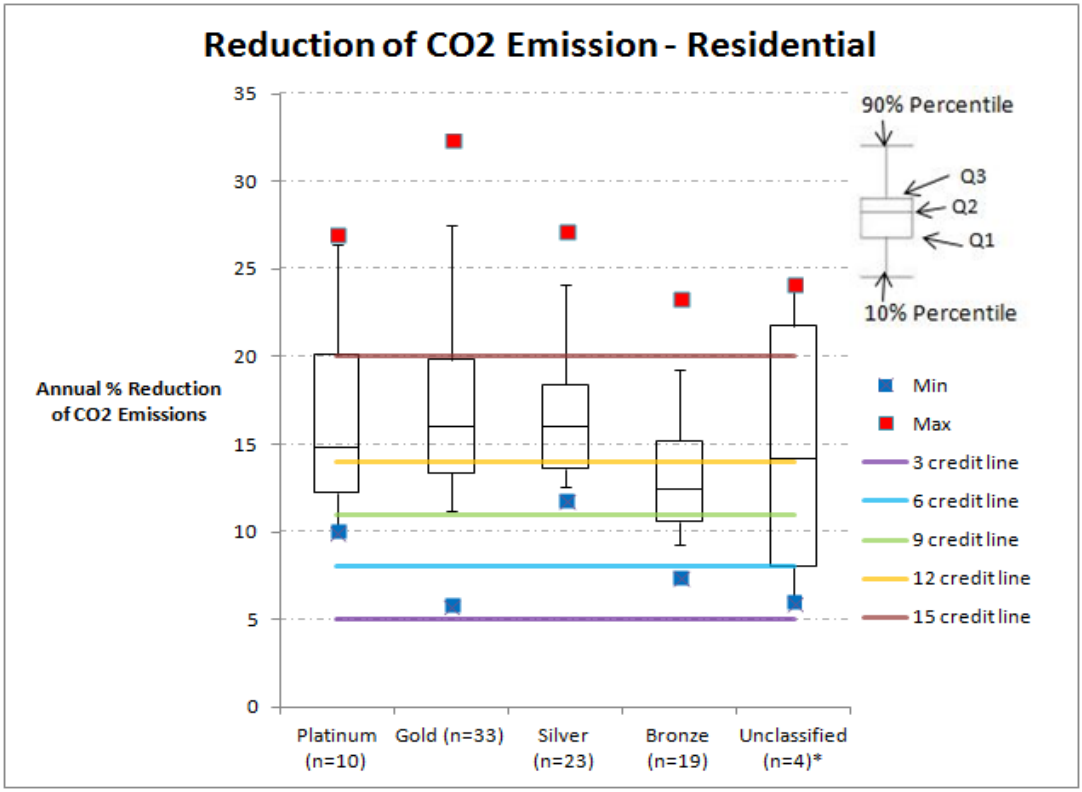


Figure 4.6: Box Plot of Reduction of CO2 Emission for Residential Buildings

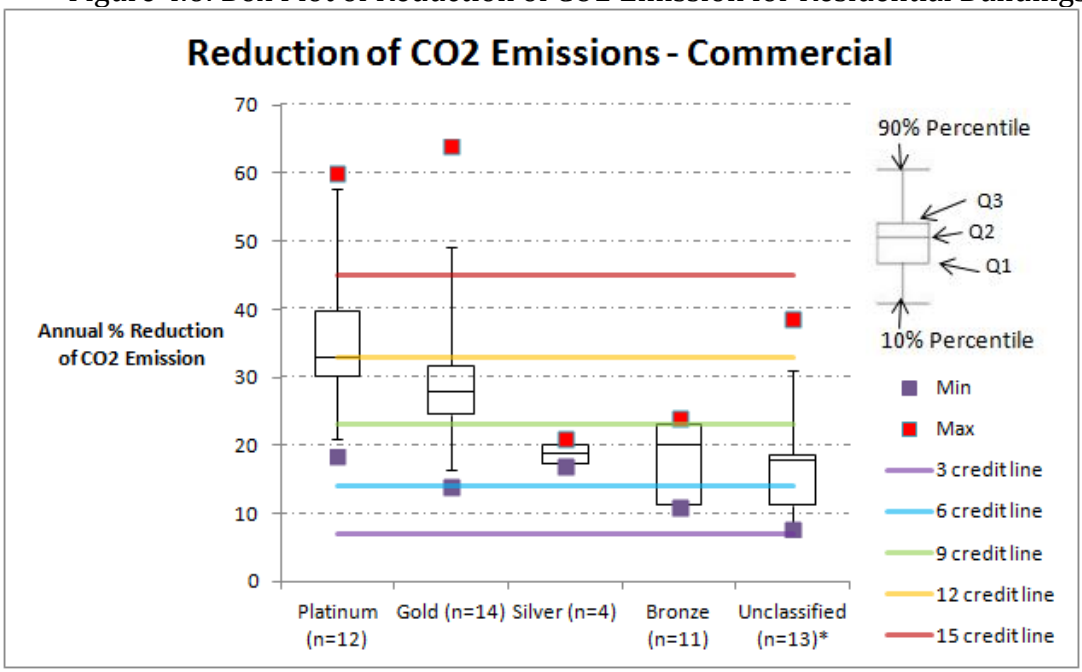


Figure 4.7: Box Plot of Reduction of CO2 Emissions for Commercial Buildings

The Unclassified box plots only present the distribution of reductions in emissions that were above 0%. 71% of Unclassified projects reported no reduction at all, so the true

medians would be 0. For comparative purposes, we are only showing the Unclassified projects that submitted for EU1 and the respective reported reduction in CO2 emissions.

The sample sizes between Residential and Commercial buildings vary significantly. Useful conclusions will be difficult to draw from Unclassified Residential buildings and Silver Commercial Buildings because of their small sample sizes. What can be observed comparing these two buildings types is that Commercial buildings do indeed achieve higher marks of reduction in CO2 emissions. However, the variance between BEAM Plus grades within Residential and Commercial buildings is much different. Silver certified Residential buildings and above grades all showed at least 50% of buildings achieved at least 15% reductions in CO2 emissions, which indicates at least 12 EU1 credits. The distributions between BEAM Plus grades in Commercial building are not as similar. For example, 50% of Platinum Commercial buildings achieve over 33% (12 EU1 credits) reduction in emissions, but less than 25% of Gold Commercial buildings report similar reductions.

4.1.7 Contested Credits Analysis

Our group completed a contested credits matrix of all 210 BEAM Plus (New Buildings scheme) buildings. The trends we found were that often credits were rarely contested, and most of the time for specific project related reasons, such as failures to submit paperwork. However, some credits were consistently contested for similar reasons, such as MA 4 and WU 2.

MA 4, Adaptability and Deconstruction, is divided into three subsections, which contain different checklists of items needed to comply with for achievement. Excluding Unclassified projects, where none applied for these credits, nearly 16% of all projects

were contested for each of these sub-credits. Typically projects provided insufficient evidence they can demonstrate flexibility of structure throughout the site, or cannot demonstrate why certain items are non applicable to the project. 37.3% of all projects apply for MA4 credits, but of those projects, 37.9% are contested and did not receive credit. MA4 is so frequently contested that we believe there are common misconceptions about what the credits actually demand in the scheme document.

WU 2, Monitoring and Control, is an exceptional contested credit. Only 33 out of 209 project applied for this credit, but only 7 received credit and another 20 projects were contested. This is exceptional because WU credits typically are rarely contested. The contested reasons cite that projects demonstrate insufficient water leakage detection systems. It is alarming that not also do most BEAM Plus projects have no intention installing water leakage detection systems, but that when they do, BEAM Plus assessors feel the majority of applicants have misinterpreted the credit requirements.

4.2 Operations and Impacts of Green Technologies and Features

Based on our public tours of two BEAM Plus Platinum certified buildings, we learned how green technologies were implemented and how green features were applied. After interviewing building managers of three BEAM Plus Platinum certified buildings, we determined how green features and technologies currently benefit environmental sustainability.

Two buildings that we toured were a temporary government office (Building A) and a low-carbon demonstration building (Building B). We interviewed the building managers of three buildings, an estate of high technology industries (Building C), an aged public housing estate (Building D), and an old low-rise office building (Building E).

4.2.1 Public Tours

When we toured Building A we noticed two major problems with the implementation of green technologies: natural daylight and natural ventilation.

Figure 4.8: Building A - Natural daylight and ventilation not in use

First, the building achieved the daylighting credit in the Final Assessment report, but the shades on the windows were closed on 3 of the 4 sides of the building. We believe that the occupants prefer the brightness of artificial lighting over natural lighting. Unfortunately, we could not interview occupants of this building, so we do not know the specific reason why occupants prefer to keep the shades down. Second, the building applied for the natural ventilation credit, but all of the windows were closed. We think that the main reason the windows were closed is noise related because the building is underneath a highway and very close to a busy road. The IEQ credit concerning background noise control was also not achieved, leading us to believe the noise levels are indeed distracting for occupants. A summary report with our observations and analysis of Building A can be found in Appendix T.

We demonstrated the impacts of some non-implemented credits. For example, if a building applies for natural ventilation, but does not provide a means to reduce the noise from the outdoors, the building occupants are going to keep the windows shut most of the time. This poses a problem for buildings to apply for both natural ventilation credit and background noise isolation credit, and a solution is needed.

Our observations of Building B, a low-carbon demonstration building, had a different focus than at Building A.

Figure 4.9: Building B - Natural daylight and ventilation in Use

Building B applied for both natural ventilation and daylighting credits, and both of these credits were being satisfied during our visit. Using our observations we think both of the natural ventilation credits were successfully implemented at Building B because there the tour highlighted these features and many windows were open, allowing for a comfortable indoor environment. We think that the daylighting credit was successfully implemented because measures were in place to prevent direct sunlight from shining in the eyes of people in the building.

Our observations and analysis at Building B focused on the bio diesel generator, which helped to reduce energy consumption and carbon emissions. This building uses solar panels and a biodiesel generator to generate enough energy to power the building. We learned during the tour that the bio-diesel generator had broken down many times since the opening of the building in 2012, which has prevented the building from achieving zero carbon emission in years prior to 2015. Maintenance on the generator was slow because parts had to be shipped from Switzerland.

This building installed a variety of green features, such as a light pipe, high-volume-low-speed fans and so on, to demonstrate how green technologies can be implemented in Hong Kong buildings. A summary report with our observations and analysis for Building B can be found in Appendix U.

4.2.2 Interviews

By interviewing building managers of Platinum certified buildings, we studied more about occupant awareness and management of green buildings. Our emphasis during these interviews was on the specific challenges of maintaining a balanced efficiency of resources and unique problems caused by occupant behaviors. Building C is certified under the BEAM Plus New Buildings scheme, and Buildings D and E are certified under the BEAM Plus Existing Buildings scheme.

4.2.2.1 Building Manager Interview for Building C

We conducted an interview with the senior manager of the facilities management for Building C, a BEAM Plus Platinum certified estate of high technology industries, to obtain information on the buildings within the site, ranging from occupant awareness to technological upkeep.

With regards to public awareness, the facilities manager explained that, in their opinion, the employees working in the site are more receptive to sustainable buildings than other Hong Kong people. The facilities manager believed nearly all occupants are unaware of BEAM Plus certification. To combat the low awareness of BEAM Plus, Building C educates the local community through green building exhibitions, computer aided interactive green trails, and a living laboratory or showcase. However, the facilities manager believed BEAM Plus needs a stronger marketing campaign to increase demand for more BEAM Plus buildings. The manager also felt low acceptance of green building practices may prevent clients from looking to build green buildings, making it difficult to improve the standard of building environmentally sustainable buildings.

Building C had several challenges operating the building by design. The most notable challenge is lowering reliance on the AC system, which reduces humidity in the summer while still keeping high occupant satisfaction. The Building-Integrated Photovoltaics (BIPV) panels had to connect to the general electrical grid through an inverter, which is not financially viable. Repairs of the panels are too expensive, which is equivalent to 5 years of savings in electricity from the panels. Ultimately, the BIPVs proved to be economically inefficient. Also, the wind turbine, a small 5kW model, frequently was shut down during periods of high winds (typhoons) so as to reduce any potential damage.

Building C's energy usage from air conditioning and artificial lighting is so high that contributions from solar and wind energy are insignificant, so this building's savings focus on the reduction of air condition and lighting usage. The focus on better management of resources is seen in both throughout the analysis of credit achievement

rates and in practice. Occupants in this building are more willing than others in Hong Kong to assist to sustainability efforts, such agreeing with as limiting their reliance on air conditioning. Application of LEDs has reduced energy consumption, and low end products are unreliable.

For water reduction, the facilities manager said the facilities team observed a 20-30% annual reduction in water consumption from tap flow water in sinks (regulated flow). Future plans include condensation water harvesting along with the reduction of water footprint. Rainwater collection is solely used for irrigation.

In terms of waste management the facilities manager said they are installing more hand dryers instead relying on paper towels in the bathrooms. Their food waste program hires contractors to collect the buildings food waste to be processed into fish food.

Overall, the two key points we took out of the interview were that new green technologies are still too expensive with lengthy payback periods and management of resources was the easiest way to attain more sustainable buildings.

4.2.2.2 Building Manager Interview of Building D

We were gratefully given the time to interview the building managers of Building D, a Platinum-certified, aged public residential estate. The company overseeing the project, which will remain anonymous, was interested in renovating more of their existing buildings to be more sustainable. Building D was a trial run to judge how effective using BEAM Plus enhanced the building's efficiency and management.

The buildings managers of Building D had prepared a presentation about the methods and challenges of attaining BEAM Plus certification. Despite the building having been in operation for over 40 years, Building D attained a Platinum rating through

meticulous management, without the need to invest in ‘green’ features such as renewable energy or soft landscaping. Extensive care went into following specific ventilation guidelines, energy consumption management, and installation of handicapped accessibility amenities. This building educates their staff to operate under the BEAM Plus standards and monthly local community meetings to educate residents about living more sustainably. Despite 30% of the elderly having lived in the building before its renovation and certification, the residents were very open to changing their habits to be more sustainable.

During certification, the buildings managers’ first priority was the budget, because they want to efficiently use their government-funded money. They were concerned that implementing more energy efficient technologies, such as solar panels and oil free chillers, which would not see any life cycle cost benefits. Investing in stronger management was inexpensive and more adaptable to the structural integrity of the existing building.

4.2.2.2 Building Manager Interview of Building E

We conducted an interview with the building manager of Building E, a Platinum certified, low rise office building. During the interview, we discussed the overall maintenance of the building and some challenges faced with maintaining green technologies.

Regarding occupant behavior, the building manager informed us that neither he nor the occupants had ever turned off any of the green technologies. Because efficient use of resources can reduce the cost of rent, the building manager encourages the office workers to switch off the AC and limit their usage of water and light.

We learned about the reliability of two green technologies, LED lighting panels and the oil-free chiller. Technology is reliable if it requires few repairs and is easy to maintain. Two different brands of LED lighting panels were installed in the building, one brand being more reliable than the other. The building manager had to order more to replace some of the unreliable panels. The oil-free chiller was much more reliable than the lighting panels, as the building manager didn't express any problems with the chiller. The compressor in the chiller was maintenance free and did not require to be monitored. The technology has been around for about 15 years, and the initial expensive cost is the only reason why it is not widely used in Hong Kong.

In regards to BEAM Plus signage, there is a plaque demonstrating the building's BEAM Plus certification located in the corner of the lobby, away from where a typical visitor or occupant would find it.

The building manager has had experience managing both green and non-green buildings, and he feels there are not many differences between maintaining the two. However, one major difference is that many green certified buildings apply for the testing and commissioning credits. These credits require daily testing to be carried out to ensure that the building operates close to the designed efficiency of the building. The testing ensures that certain technologies, such as the air conditioner, do not deteriorate over time. Satisfying these credits increase the cost of maintenance of the building.

4.3 Occupants' Perceptions and Satisfaction

To comprehend occupants' perceptions of green buildings, we conducted occupant surveys in two BEAM Plus platinum certified buildings, University A, a business school, and University B, a tertiary college. Neither building educates occupants

about green buildings, nor occupants only had very basic perceptions about green features and energy efficiency. The questionnaire, both in Traditional Chinese and English, is in Appendix S.

4.3.1 Awareness of Green Certifications

To learn the occupants' awareness of green certifications, we compiled 200 responses from occupants collected in University A and B. The pie chart in 4.10 shows the results of Question 1: "Are you aware that this building is a green certified building? If yes, please provide the name of the certification scheme."

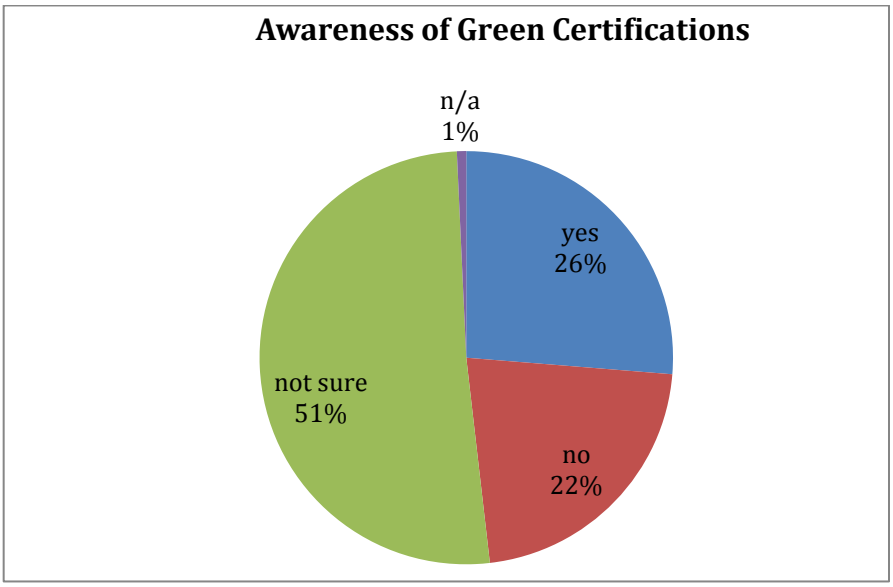


Figure 4.10: Awareness of Green Certifications

Most surveyed people had little knowledge about the concept of green buildings and the BEAM Plus certification scheme. Some of the people that answered yes to the building being green asked us, "what is a green building?" when they were filling out the questionnaire. Most occupants likely answered "not sure", because they either didn't know the definition of 'green building' or were not sure if the building was certified. When we were taking our own observations of the buildings, we didn't see any BEAM

Plus signage or green building education information in the buildings. Since occupants aren't educated about green buildings, their awareness of green buildings is low. Additionally, we also asked for the name of the certification scheme on the questionnaire, but nobody knew that it was BEAM Plus.

4.3.2 Green Features

Most surveyed people knew there were some green features in the building, but they only had a basic understanding what is considered a green feature. The following figure, Figure 4.11, shows pie charts with the responses to Question 2: "Do you think this building has green features? Please elaborate."

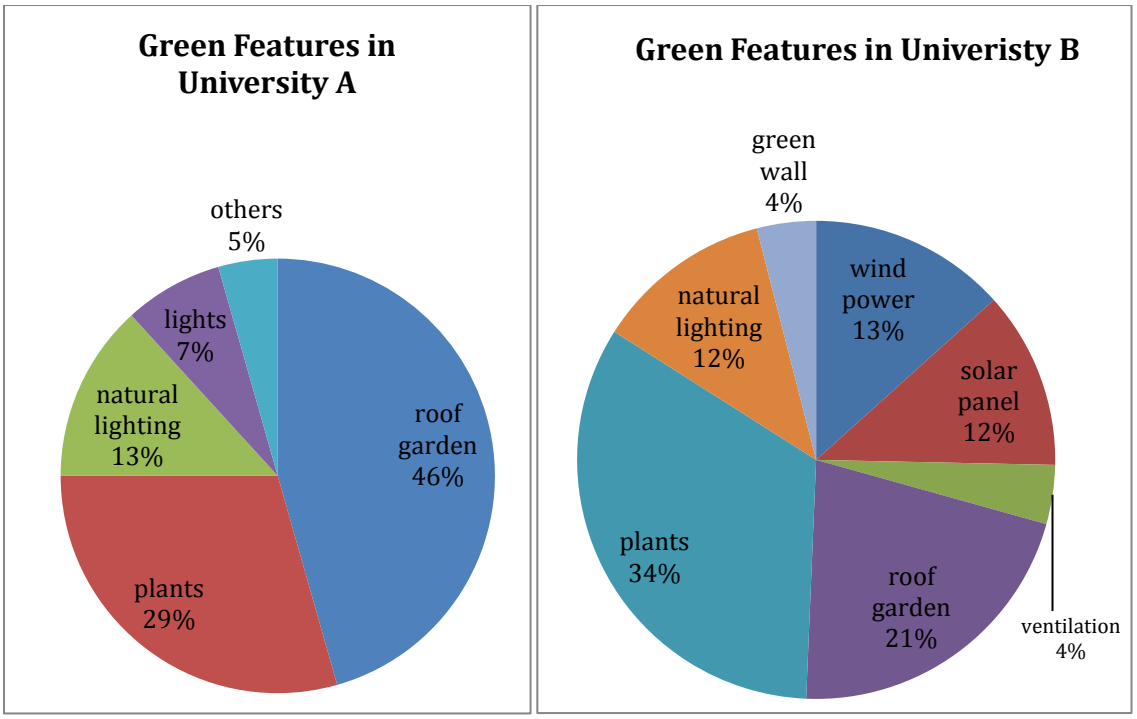


Figure 4.11: Detailed Green Features Responses

Most people noticed green features based off of the color green, such as roof gardens, plants, trees and green walls. A few people had knowledge about basic green technologies, such as wind turbines, which have been widely implemented throughout the

world. Some people realized lighting features including natural lighting and light sensors, and five people mentioned materials, like bamboo decorations. However, no one mentioned water saving technologies, such as dual-flush toilets and rainwater harvesting systems. This data show that the occupants are lacking knowledge about green technologies.

4.3.3 Energy Efficiency

While many people did not have a clear understanding of green technologies, the vast majority of the people did have general ideas about energy efficiency. Figure 4.12 shows the responses to Question 3: "Do you think this building is energy-efficient? Please elaborate." Of the 36 people who responded yes to Question 1, 9 people did not believe the buildings were energy-efficient (answered no to Question 3) and 10 people were unsure. The result indicates that nearly half of the people believe that certified green buildings do not guarantee the building also being energy efficient, and this perception might have led them to answer not sure for Question 3. However, as shown from results of Question 1, some occupants believe the only quality green buildings must have are literally green features, so perhaps these respondents are unaware that a green building must also be energy efficient.

We also learned, as shown in Figure 4.12, occupants in University B had a better understanding of energy efficiency than occupants in the University A, because they list more of a variety of energy efficient features.

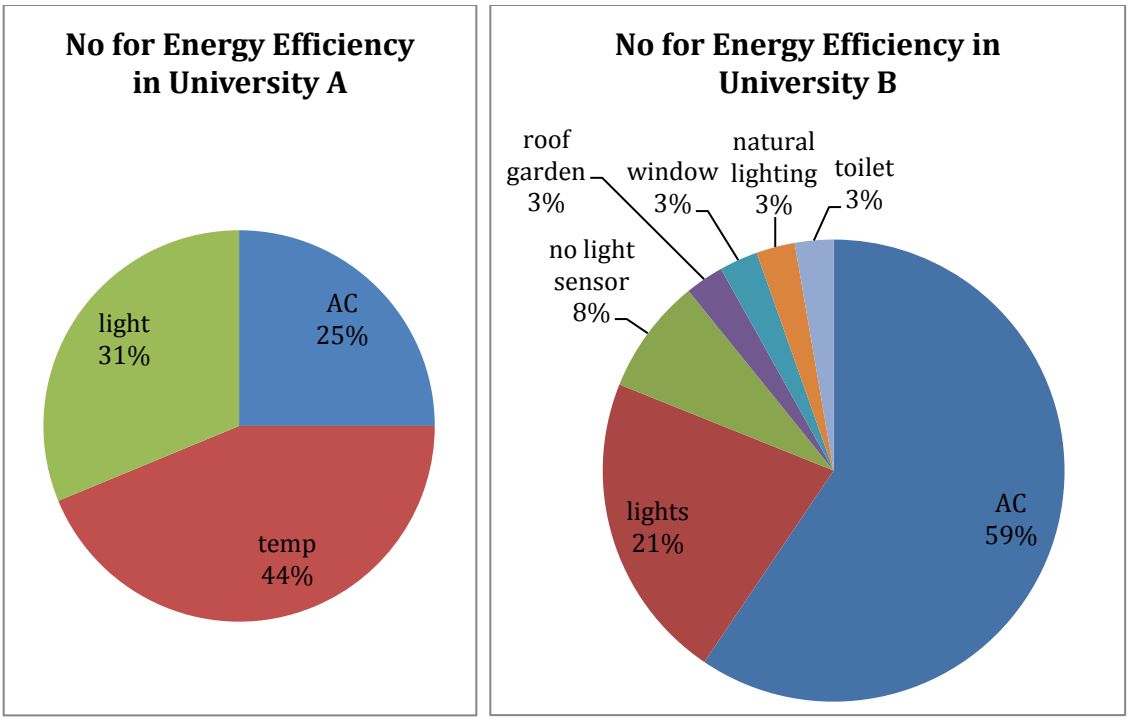


Figure 4.12: Reasons Respondents Answered No for Energy Efficiency

People who answered no to Question 3 from both buildings remarked that the usage of air-conditioners and temperature settings was uncomfortable. However, as shown in Figure 4.13, nobody mentioned anything about the air-conditioner and temperature when they answered yes for Question 3. Thermal comfort varies from person to person. Therefore, some people would prefer the AC to be comfortable, but other people believe it is a waste of energy to keep the AC on.

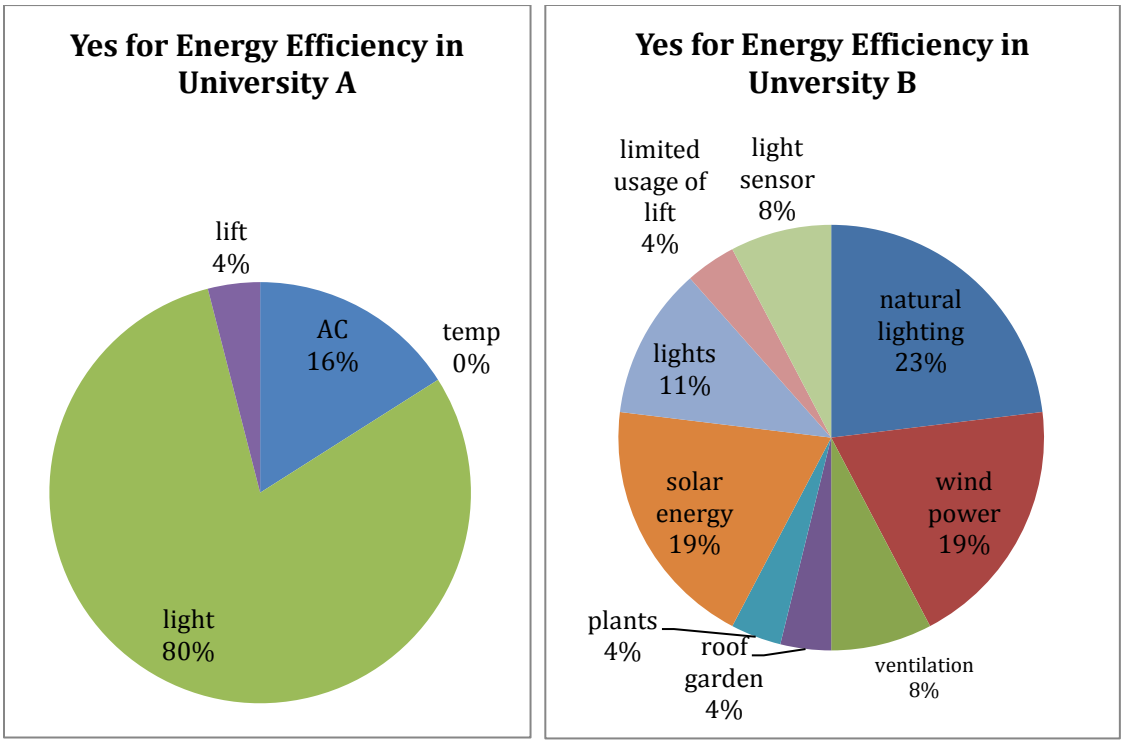


Figure 4.13: Reasons Respondents Answered Yes for Energy Efficiency

4.3.4 Indoor Environment Satisfaction

Indoor environmental comfort is hard to form conclusions about because it depends on people's preferences, which is complicated to define as good and bad. To learn about occupant satisfaction, we used Question 4: "Are you satisfied with the indoor environment in the classroom, for example: temperature, air quality, lighting? Please elaborate." As we can see in Figure 4.14, 45% of the people approved of the indoor environment, another 45% of the people didn't enjoy the indoor environment, and 10% of the people didn't have a specific preference about the indoor environment.

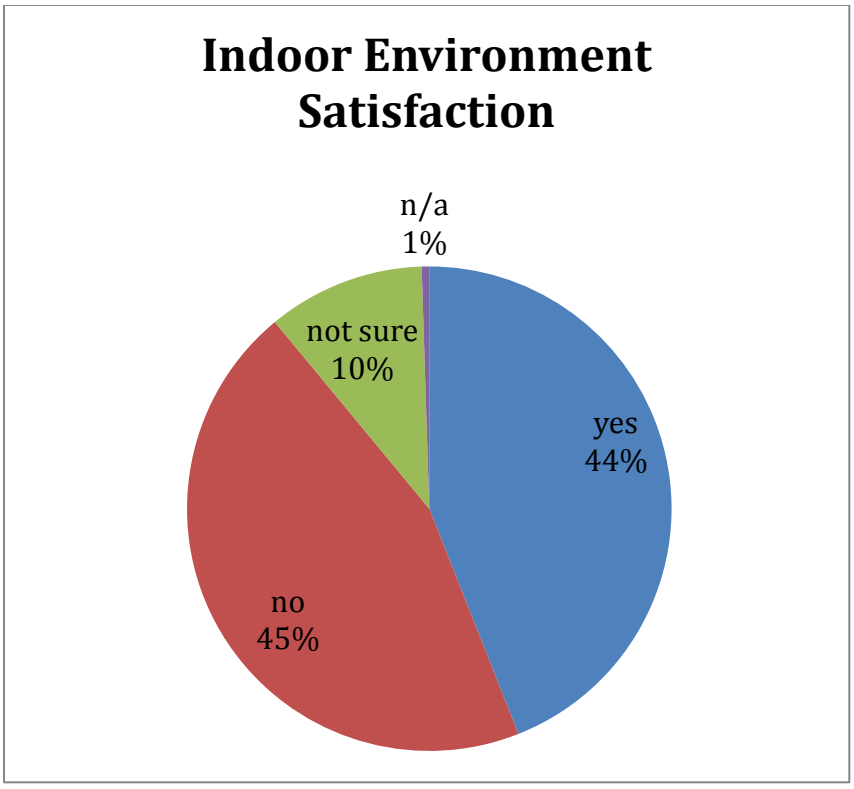


Figure 4.14: Indoor Environment Satisfaction

In Figure 4.15, occupants who felt the indoor environment was uncomfortable felt that the temperature was "too cold", but didn't mention anything about lighting or air quality. The majority of the people who were satisfied with the indoor environment cited reasons like lighting, and some people also commented the building had a moderate temperature. However, not many people stated any complaints or satisfaction about air quality.

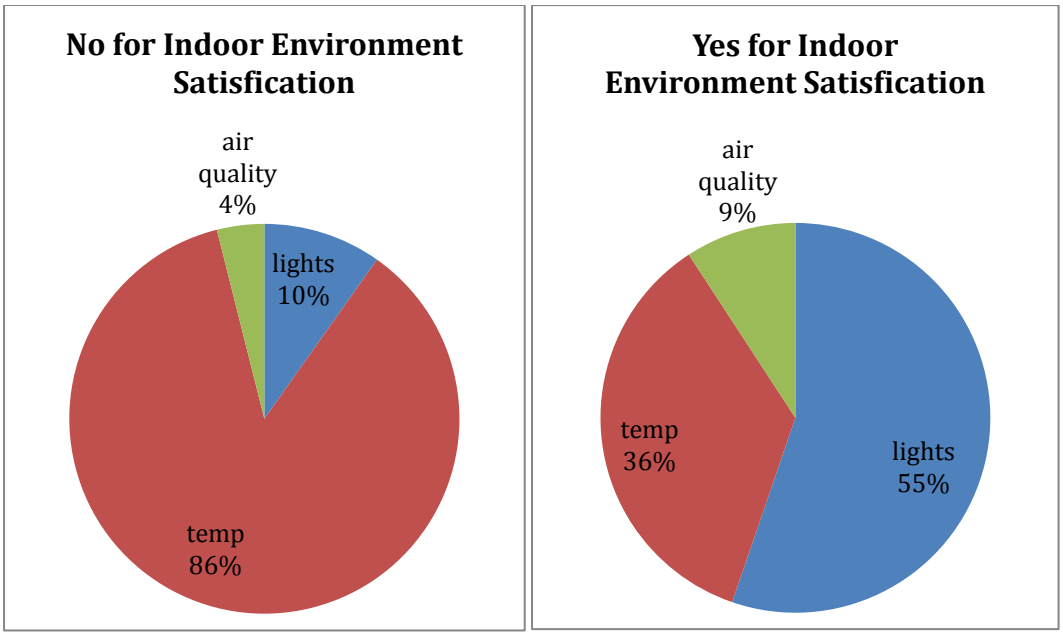


Figure 4.15: Responses of Indoor Environment Satisfaction of University A and B

4.4 Summary

By analyzing both qualitative and quantitative information of all projects, we demonstrated the strengths and weaknesses of BEAM Plus credits and provided analysis about problematic credits. We compared V.1.1 projects and V.1.2 projects to understand the impact of changes in criteria, and found efficient methods to increase feasibility of credits. To summarize our findings from public tours and questionnaire surveys, we examined how green technologies and features were implemented and learned about occupants' perceptions of green buildings. Occupants' behaviors influenced many buildings not to implement all green features, such as natural lighting and natural ventilation, as stated in the assessment reports, and many occupants were not aware of the overall concept of green buildings. In the next chapter, we will provide recommendations to increase the feasibility of credits and the awareness of occupants, and make

suggestions about government regulations to increase the impact of green buildings on the environment.

5.0 Conclusion and Recommendations

In this chapter, we provide our recommendations to improve the BEAM Plus rating scheme to stimulate a positive shift in building standards in Hong Kong. We review strengths and weaknesses of the BEAM Plus scheme based on our archival research and provide our suggestions for improving BEAM Plus credits to push buildings toward sustainability. We identify the gaps between theory and practice of building maintenance by studying how effectively green technologies and features are maintained and implemented in BEAM Plus buildings. We suggest how to educate and improve awareness of green certification according to our observations of occupant behavior. To provide incentives for certifying more green buildings, we give our recommendations for the Hong Kong government to expand their support for the BEAM Plus scheme. Finally, we recommend additional research for future projects.

5.1 Conclusions

The HKGBC's mission is to enhance building standards in Hong Kong, and that requires regular modification of the BEAM Plus scheme. BEAM Plus is already effective at addressing a wide variety of environmental issues in Hong Kong, as we saw in our building visits. BEAM Plus is particularly effective in stimulating strong maintenance management programs. However, BEAM Plus struggles to encourage buildings to rely on new sustainable and energy efficient technology. Credits are only evaluated on an individually from one another, and BEAM Plus could use a more integrative approach to ensure stronger building performances and prevent conflicting features in design. Some standards cannot adequately apply to all building types or some criteria may not continue

to be relevant or appropriate for Hong Kong as technologies or circumstances change. The descriptions of the BEAM Plus credits also occasionally can be unclear for the applicants. Our suggestions for modifying specific BEAM Plus credits to address problems are followed up in our recommendations section.

The gaps between theory and practice of building maintenance are prevalent with respect to green technologies. Initial costs and repair fees of currently available green technologies are too high for most buildings to consider implementing. Technologies that harness renewable energy, for example solar panels, have low efficiency rates and low financial viability. The HKGBC cannot actively solve this problem, and the manufacturers and engineers need to take responsibility and continue developing green technologies that can be both energy efficient and financially viable options for Hong Kong.

The occupants of the Platinum rated buildings we visited were unaware of BEAM Plus or even what a green building is. If even occupants of BEAM Plus certified buildings are unaware of BEAM Plus, the general public is even less likely to be aware of this rating system. Occupants' perceptions influence their behavior, which directly impacts the effective use of green features. Therefore, it is important to educate the public about sustainability, and in particular how to become aware of the importance and proper use of green buildings to combat Hong Kong's environmental problems.

The Hong Kong government supports BEAM Plus by granting buildings to expand their gross floor area by 10% for free if they are certified by at least BEAM Plus Unclassified. This has produced many Unclassified buildings with nearly all credits not submitted. Unclassified projects are now the largest category among BEAM Plus grades,

so we conclude that this regulation has been ineffective in incentivizing the construction of more sustainable buildings.

5.2 Suggestions for BEAM Plus

Based on our research, we give the HKGBC three general recommendations on how to improve BEAM Plus standards. First, raise standards for easily achieved credits. This is not an easy task as not all credits are expected to have high achievement rates, and others are meant to be easily achieved. We believe that adjusting the standard to be higher for credits projects easily achieve can push buildings toward more innovative and sustainable benchmarks. Second, rework standards for never achieved credits. These credits that are never achieved suggest a problem with feasibility, and can be adjusted to be more appealing for projects to at least try to implement the credits. Third, revise standards for infrequently achieved credits. For example, the HKGBC changed IEQ 15, the daylighting credit, from V.1.1 to V.1.2 by lowering the required factor of daylight to be more easily achievable, and the result was higher achievement and submittal rates for this credit.

The following are specific recommendations to improve BEAM Plus credits based on our archival research and site visits.

The most obvious problem with the Site Aspects credits was SA8b, Microclimate - Elevated Temperatures. Two credits are offered but one credit regarding non-impervious roofing materials is almost never attempted, leading to a low overall achievement rate. We recommend the HKGBC to revise their guidelines for the non-impervious roofing materials credit by re-defining what is considered a non-roof surface.

We also recommend the HKGBC research into reasons why guaranteeing canopy shading can be so difficult for projects to achieve and if the standard of 50% shading is too high.

For Material Aspect credits, most of the required materials, such as rapidly renewable materials and recycled materials, cannot be used to construct specific parts of the buildings. The current challenge for buildings using rapidly renewable and recycled materials is a lack of common techniques for using these materials in high-rise buildings while maintaining their structural integrity. We recommend that more research needs to be carried out to determine effective uses of rapidly renewable materials and recycled materials in high-rise building structures. For example, coating a rapidly renewable material with a fire retardant could be used to improve fire spread performance inside a building. More floor and wall tiles can be made of recycled materials without sacrificing their appearance and hardness. Appropriate testing standards could be set up to assure the quality of the materials, if such changes to the standards were made.

From the results regarding water usage credits, projects attain full achievement of annual water savings (WU1) with ease through low flow sanitary fittings. We recommend revising the baseline standard upwards. Buildings easily reduce their annual water consumption and achieve the highest required savings factor by installing low flow fixtures without implementing any other water saving features such as grey water tanks. Currently, BEAM Society assumes that most buildings use faucets with 8.3 L/min flow rates, as stated in the BEAM Plus manual. So many buildings successfully lowering their flow rates, we recommend the HKGBC investigate if this is too high of an assumption since lowering the flow rate is relatively easy for projects. This could push these

buildings to start investing in other methods to lower water consumption, such as infrared sensors in bathroom sinks.

For IEQ credits, BEAM Plus looks at each of these aspect in isolation. Buildings cannot adequately claim to implement natural ventilation if they cannot also demonstrate they can limit background noise coming from outside the building. This means to achieve a credit for natural ventilation, the designer also has to justify how other effects of opening a window, like noise, air pollution, and pest control, are suitably evaluated and proven to be acceptable. Another example is natural lighting. To be effective, the window glazing should be properly selected to resist heat or the building's orientation should be suitably chosen to avoid direct sunlight coming through windows. The window blinds have to be translucent instead of opaque. To create a sustainable indoor environment, designers must take integrative approaches.

For conversion projects, we determined that such projects were scoring low because the rating scheme is not designed to accommodate for such projects. Eleven credits were found to be unrealistic for conversion projects to apply for. A list of these credits with reasons for being unrealistic is found in Appendix O. We recommend that the BEAM society assign these credits as Not Applicable for conversion projects. This change could increase the scores of conversion projects, and provide a step in the right direction towards helping conversion projects achieve higher ratings.

5.3 Public Awareness

We recommend that the HKGBC implement stronger educational strategies to increase public awareness. We have discussed how the public was found to have poor

awareness of BEAM Plus, and it is important for them to learn how they can maximize green buildings' environmental performance.

Our first suggestion for HKGBC is to require a statement to be placed on all major entrances of BEAM Plus Provisionally Assessed buildings explaining that they are both working towards achieving BEAM Plus certification and their dedication to sustainable building. Currently, buildings only receive a BEAM Plus certification plaque when they receive their final certification and there are only 6 out of 210 assessed buildings that have achieved their final assessment, meaning there are few opportunities to showcase their dedication to building sustainably. In order to increase public awareness, more opportunities to display BEAM Plus certification is needed.

Our second suggestion is that all BEAM Plus certified buildings should be required to post signage next to four green technologies located throughout the buildings to educate the occupants about the environmental benefits of the green features.

Our third suggestion is the credits within the rating tool should include new requirements on occupant education to properly use the green equipment. For natural ventilation, stickers on windows can remind occupants how they can employ natural ventilation during suitable times of the year. For natural lighting, tenants should be educated to use translucent blinds rather than opaque blinds. Dual-flush toilets should include labels to help occupants to use the equipment.

Our fourth recommendation for the HKGBC is to study the occupant satisfaction of BEAM Plus buildings after their first year of operation. By this time, the building will be fully occupied and occupants' habits will be established. This post-occupancy survey

will help judge if BEAM Plus certified buildings are creating both sustainable and comfortable living environments.

5.4 Government Regulations

The Hong Kong government already promotes BEAM Plus through encouraging certification of buildings expanding their gross floor area (GFA). Yet this government program has produced many Unclassified buildings that had no interest in applying for any of the BEAM Plus credits. We recommend the government strengthen the guidelines for granting GFA concessions.

Our recommendation for the Hong Kong government is to provide grants or subsidies to qualified buildings to help pay for some of the initial expenses for effective but expensive technologies such as solar heat pumps, high-performance glazing, and oil-free chillers. Often buildings are limited by the initial costs of the BEAM Plus certification process and the addition of new green features. This could promote BEAM Plus as a standard for buildings to follow, as well as provide resources for more innovative practices to emerge. This regulation would provide applicants the incentive to explore new green features. Government funding or subsidies could increase the demand for sustainable features, thus lowering their initial costs, and allowing green features to be more feasible and commonplace in Hong Kong.

5.5 Additional Research

Buildings of different types and grades should be visited and surveyed to study a wider range of occupant behavior and building management.

We conducted case studies of only BEAM Plus Platinum certified buildings, so we recommend the HKGBC to replicate this study for Gold, Silver, and Bronze

buildings. To understand occupant perceptions, we surveyed occupants of two universities, and we advise a future project to focus on residential, commercial and industrial buildings. This future research could compare different building types at the same BEAM Plus certification level, or different certification levels of the same building type. Surveys of varied building types and certification levels would allow researchers to analyze a more diverse population with a greater variety of perceptions of green buildings than what we found. Site visits and manager interviews would provide insights to the challenges of implementing green features in all building levels and types.

5.6 Impact of Our Project

Our project results and recommendations can help our sponsor, the HKGBC, to shrink the gaps between theory and practice of BEAM Plus standards. Improving these standards could stimulate more sustainable buildings in Hong Kong and shift the public's perceptions and behavior toward greener lifestyles. By developing more buildings with designs that consider their environmental impact, we hope that a greater demand for green buildings around the world may be seen, thus helping address the challenges of climate change.

References

AGC_of_America. (2009). Climate Change and the Construction Industry. Retrieved November 12, 2014, from http://www.agc.org/galleries/advy/ClimateChangeandConstruction.pdf

Altomonte, S., & Schiavon, S. (2013). Occupant satisfaction in LEED and non-LEED certified buildings. *Building and Environment, 68*, 66-76.

Architectural Services Department. (2014). Green Contractor Award. Retrieved December 6, 2014, from http://www.archsd.gov.hk/en/knowledge-sharing/green-contractor-award/2013.aspx

BCA. (2014a). About BCA Green Mark Scheme. Retrieved November 22, 2014, from http://www.bca.gov.sg/GreenMark/green_mark_buildings.html

BCA. (2014b). BCA Green Mark Assessment Criteria and Application Forms. Retrieved November 22, 2014, from http://www.bca.gov.sg/GreenMark/green_mark_applnforms.html

Lists the applications available to the public, specifically potential clients, that the BCA Green Mark will use to evaluate buildings.

BCA. (2014c). BCA Green Mark Assessment Criteria and Online Application. Retrieved November 22, 2014, from http://www.bca.gov.sg/greenmark/green_mark_criteria.html

BEAM Society. (2010a). BEAM Plus for Existing Buildings 1.1. Retrieved November 20, 2010, from https://www.hkgbc.org.hk/upload/beamdocuments/beamplusdoc/BEAM-Plus-1-1-EB.pdf

BEAM Society. (2010b). BEAM Plus for New Buildings 1.1. Retrieved November 20, 2014, from https://www.hkgbc.org.hk/upload/beamdocuments/beamplusdoc/BEAM-Plus-1-1-NB.pdf

BEAM Society. (2012a). About BEAM. Retrieved December 5, 2014, from http://www.beamsociety.org.hk/en_about_us_0.php

BEAM Society. (2012b). BEAM Plus for Existing Buildings 1.2. Retrieved November 20, 2014, from http://www.beamsociety.org.hk/files/BEAM_Plus_For_Existing_Buildings_Version_1_2.pdf

BEAM Society. (2012c). BEAM Plus for New Buildings 1.2. Retrieved November 20, 2014, from http://www.beamsociety.org.hk/files/BEAM_Plus_For_New_Buildings_Version_1_2.pdf

BREEAM. (2014). What is BREEAM? Retrieved November 22, 2014, from http://www.breeam.org/about.jsp?id=66

Carroll, J. M. (2007). *A Concise History of Hong Kong*. Lanham, MD: Rowman & Littlefield Publishers.

Chan, K. K.-l., Bridges, B., & Chen, A. H. Y. (2008). *"One Country, Two Systems" In Crisis: Hong Kong's Transformation Since The Handover* (Y.-c. Wong Ed.). Lanham, MD: Lexington books.

Crespi, J., Rangle, R., Webb, C., & Zhang, L. (2014). *Understanding and Improving Green Building Standards in Hong Kong*. Unpublished Interactive Qualifying Project. Worcester Polytechnic Institute.

Ding, G. K. (2008). Sustainable construction—The role of environmental assessment tools. *Journal of environmental management, 86*(3), 451-464.

Government of Hong Kong. (2014 December). *Government's Efforts in Promoting Green Buildings*. Retrieved from http://www.gov.hk/en/residents/environment/sustainable/buildings.htm.

Government of Hong Kong Special Administrative Region. (2014). The 2014 Policy Address *Support the Needy, Let Youth Flourish, Unleash Hong Kong's Potential* (pp. 54). Retrieved from: http://www.policyaddress.gov.hk/2014/eng/pdf/PA2014.pdf

Haapio, A., & Viitaniemi, P. (2008). A critical review of building environmental assessment tools. *Environmental Impact Assessment Review, 28*(7), 469-482. doi: http://dx.doi.org/10.1016/j.eiar.2008.01.002

Hoffman, A. J., & Henn, R. (2008). Overcoming the social and psychological barriers to green building. *Organization & Environment, 21*(4), 390-419.

Hong Kong Green Building Council. (2014). Hong Kong Green Building Council. Retrieved November 15, 2014, from https://www.hkgbc.org.hk/eng/index.aspx

Lee, W. L., & Burnett, J. (2008). Benchmarking energy use assessment of HK-BEAM, BREEAM and LEED. *Building and Environment, 43*(11), 1882-1891.

Richards, J. (2012). GREEN BUILDING: A Retrospective on the History of LEED Certification: Sustainable Industries. *Institute for Environmental Entrepreneurship*.

Scofield, J. H. (2013). Efficacy of LEED-certifaction in reducing energy consumption and greenhouse gas emissions for large New York City office buildings *Energy and Buildings* (Vol. 67, pp. 517-524).

The Government of the Hong Kong Special Administrative Region. (2003 September). A Guide on Indoor Air Quality Certification Scheme for Offices and Public Places. In Indoor Air Quality Management Group (Ed.): Government of Hong Kong.

The Government of the Hong Kong Specia Administrative Region. (2003). IAQ Objectives for Offices & Public Places. In I. A. Q. M. Group (Ed.). Indoor Air Quality Information Centre Website: Government Logistics Department.

The Government of the Hong Kong Special Administrative Region. (2013a). Background of IAQ Certification Scheme. Retrieved December 6, 2014, from http://www.iaq.gov.hk/second.asp?page=scheme&sub=background

The Government of Hong Kong Special Administrative Region. (2013b). *2013 Policy Address Policy Initiatives of Environment Bureau: Environmental Protection*. Paper presented at the Legislative Council Panel on Environmental Affairs. http://www.epd.gov.hk/epd/english/news_events/legco/files/EA_Panel_20130128a_eng.pdf

The Government of Hong Kong Special Administrative Region. (2014 May 30). *Background and Categories of Award*. Development Bureau Website: Retrieved from

http://www.devb.gov.hk/en/construction_sector_matters/contractors/considerate_contractors_site/index.html.

Turner, C., & Frankel, M. (2008). Energy Performance of LEED for New Construction Buildings. Vancouver, WA: New Buildings Institute.

United States Green Building Council. (2012). LEED credits. Retrieved November 23, 2014, from http://www.usgbc.org/credits

Worcester Polytechnic Institute. (2014). Interdisciplinary and Global Studies Division - Interactive Qualifying Project. Retrieved December 5, 2014, from http://www.wpi.edu/academics/igsd/iqp.html

World Business Council For Sustainable Development. (2007). Energy Efficiency in Buildings: Business Realities and Opportunities. Retrieved from http://www.c2es.org/docUploads/EEBSummaryReportFINAL.pdf

Yau, R., Lau, E., & Choi, M. (2014). BEAM Plus - Past, Present and Future. Zero Carbon Building Journal, 2, 30-39

Yeung, M. R., Yuen, P. K., Dunn, A., & Cornish, L. S. (1992). Performance of a solar-powered air conditioning system in Hong Kong. *Solar Energy, 48*(5), 309-319. doi: 10.1016/0038-092X(92)90059-J

Yik, F. W. H., Burnett, J., Jones, P., & Lee, W. L. (1998). Energy performance criteria in the Hong Kong building environmental assessment method. *Energy and Buildings, 27*(2), 207-219.

Appendix A: Hong Kong Green Building Council

The Hong Kong Green Building Council Limited (HKGBC) (2014) is a non-profit, member-led organization established in 2009. The HKGBC was developed to reduce the environmental impacts of buildings, set criteria for Hong Kong's unique climate and specific environment, and eventually to transform the city into a greener and more sustainable built environment. The organization was initially funded by the Real Estate Developers Association. In 2009, BEAM Society collaborated with other organizations in order to be one of the industry leaders. Now the Construction Industry Council (CIC), Business Environment Council (BEC), BEAM Society Limited (BSL), and Professional Green Building Council (PGBC) provide funds for HKGBC. The HKGBC is one of 98 members of the World Green Building Council (WorldGBC), and it became an Established Member of the WorldGBC (the highest level of membership) in November 2012.

The HKGBC seeks to lead the market transformation to the sustainable built environment in Hong Kong by guiding the development of industry standards, best practices, education, and research on green buildings (BEAM Society, 2012a). BEAM Plus New Buildings and BEAM Plus Existing Buildings were launched in 2010. BEAM Plus is an environmental rating tool designed to address major environmental issues such as ozone depletion, recycling, greenhouse gas emissions, and indoor air quality (Yau, Lau & Choi, 2014). The most recent version, BEAM Plus version 1.2 for New Buildings and Existing Buildings, was launched in November 2012. Later on in 2013, the HKGBC launched BEAM Plus Interiors to expand the existing BEAM Plus system, which aims to

fit-out, renovate and refurbish projects of non-domestic, occupied spaces specifically for Hong Kong.

In order to popularize its building environmental assessment method and lead the market transformation, HKGBC also launched the BEAM Pro Training and Examination Programme in 2010 to train BEAM professionals (BEAM Society, 2012b). In 2011, the number of BEAM professionals was more than 1,500. In 2014, the BEAM Affiliate Training and Examination Programme was launched, which welcomes practitioners or technical people who are working in related fields to gain professional qualifications in BEAM.

The Board of HKGBC (2012) is represented by the industry, and all of the 25 Directors are leaders in their respective professional fields. The HKGBC standing committee is formed as shown in Figure 6.1 below. Compared to the structure of the Board in 2013, they now have an Industry Standards Committee (ISC) and a Policy and Research Committee (P&RC) that replaced the Industry Standards and Research Committee (ISRC). They also added a Public Education Committee (PEC).

Figure 6.1: The structure of HKGBC's Board in 2014 (HKGBC, 2014)

Appendix B - Summary of Credits within BEAM Plus V.1.2 for New Buildings

Table 6.1: Summary of credits within BEAM Plus V.1.2 for New Buildings (BEAM, Society, 2012c)

	Section:	Credit Requirement:	Exclusions	Credits	Target
2	SITE ASPECTS (SA)			22+3B	
SA P1	MINIMUM LANDSCAPE AREA	Demonstrate appropriate planting on site equivalent to at least 20% of the site area.	Buildings or sites not for residential use; or residential sites less than or equal to 1,000m^2.	Required	
SA 1	CONTAMINATED LAND	1 BONUS credit for conducting a site contamination assessment and implementing measures for rehabilitation, and/or proper preparation of sites and structures adjacent to landfill sites.	Building developments on Greenfield sites and where the site contamination/ landfill gas hazard assessment and mitigation measures are statutory requirements of the project.	1B	
SA 2	LOCAL TRANSPORT	1 credit where parking capacity does not exceed the minimum requirement from government and parking is provided for carpools or shuttle service vehicles. 2 credits where no car parking is provided other than provisions intended for use by disabled persons and/or shuttle service vehicles.	None.	2	
		1 credit for availability of convenient pedestrian access to mainstream public transport.		1	
SA 3	NEIGHBOURHOOD AMENITIES	1 credit where at least 10 different basic services are located within 500m walking distance from the Site and pedestrian access to the services is available for the Site.	Emergency Service Premises (e.g. fire station, power substation, etc.)	1	
		1 credit where at least 2 different recreational facilities are located within 500m walking distance from the Site and pedestrian access to the facilities is available for the Site.		1	
		1 credit where at least 2 different recreational facilities or at least 5 different basic services are located within the Site and will be made available for public use.		1	
SA 4	SITE DESIGN APPRAISAL	1 credit for a site design appraisal report which demonstrates a proactive approach to achieve greater integration of site planning and design issues, and at least 50% of relevant sub-items of the Urban Design Guidelines in the Hong Kong Planning Standards and Guidelines are achieved.	None.	1	
		1 BONUS credit for 100% of relevant sub-items of the Urban Design Guidelines are achieved.		1B	
SA 5	ECOLOGICAL IMPACT	1 BONUS credit from SA 5 Ecological Impact can be achieved through the following: Having a site which scores less than 20% of the points in the Habitat Section of The Nature Conservation Policy – 2009 and having a site which scores less than 30% in the Biodiversity Section of The Nature Conservation Policy - 2009; or Demonstrating that appropriate design measures have been implemented to contribute positively to the ecological value of the site	None.	1B	
SA 6	CULTURAL HERITAGE	1 credit where development does not have a negative impact on sites of cultural heritage.	Sites or buildings without cultural heritage.	1	
SA 7	LANDSCAPING AND PLANTERS	1 credit for using pervious materials for a minimum of 50% of hard landscaped areas.	None.	1	
		1 credit for providing appropriate planting on site equivalent to at least 30% of the site area. 2 credits for providing appropriate planting on site equivalent to at least 40% of the site area.		2	
SA 8	MICROCLIMATE AROUND BUILDINGS	1 credit for demonstrating that no pedestrian areas will be subject to excessive wind velocities caused by amplification due to the site layout design and/or building design.	SA 8a – Sites which are located in urban zones with existing stagnant air	1	
		1 credit for providing shade on at least 50% of non-roof impervious surfaces on the site (parking, walkways, plazas) using light coloured high-albedo materials (albedo of at least 0.4).		1	
		1 credit for providing roof material that meets the Solar Reflectance Index (SRI) of 78 or vegetation roof covering at least 50% of the total roof area.		1	

		1 credit for conducting an AVA by wind tunnel or Computational Fluid Dynamics (CFD) according to the prevailing AVA methodology introduced by the Government demonstrating the optimal option is selected in comparing with different options.		**1**
SA 9	**NEIGHBOURHOOD DAYLIGHT ACCESS**	1 credit for designs for which the access to daylight of neighbouring sensitive buildings is maintained to the prescribed level.	Buildings where daylight is of no value to neighbouring properties.	**1**
SA 10	**ENVIRONMENTAL MANAGEMENT PLAN**	1 credit for demonstrating that an Environmental Management Plan for demolition/construction including Environmental Monitoring and Auditing has been implemented.	None.	**1**
SA 11	**AIR POLLUTION DURING CONSTRUCTION**	1 credit for applying adequate mitigation measures for dust and air emissions during the construction as recommended by the Environmental Protection Department; and demonstrating compliance with the air quality management guidelines as detailed in the Environmental Monitoring and Audit Manual.	None.	**1**
SA 12	**NOISE DURING CONSTRUCTION**	1 credit for providing adequate mitigation measures for construction noise for all Noise Sensitive Receivers.	None.	**1**
SA 13	**WATER POLLUTION DURING CONSTRUCTION**	1 credit for undertaking adequate measures to reduce water pollution during construction.	None.	**1**
SA 14	**NOISE FROM BUILDING EQUIPMENT**	1 credit for demonstrating that the level of the intruding noise at the facade of the potential noise sensitive receivers is in compliance with the criteria recommended in the Hong Kong Planning Standards and Guidelines.	None.	**1**
SA 15	**LIGHT POLLUTION**	1 credit for demonstrating that obtrusive light from exterior lighting meets the specified performance for the environmental zone in which the building development is located.	None.	**1**
3	**MATERIALS ASPECTS (MA)**			**22+1B**
MA P1	**TIMBER USED FOR TEMPORARY WORKS**	Virgin forest products are not used for temporary works during construction.	None.	**Required**
MA P2	**USE OF NON-CFC BASED REFRIGERANTS**	Using non-chlorofluorocarbon (CFC)-based refrigerants in HVAC&R systems.	None.	**Required**
MA P3	**CONSTRUCTION/ DEMOLITION WASTE MANAGEMENT PLAN**	Implementation of a waste management system that provides for the sorting, recycling and proper disposal of construction/ demolition materials.	Project where demolition is not required or is not under the Client's control.	**Required**
MA P4	**WASTE RECYCLE FACILITIES**	Provision of facilities for the collection, sorting, storage and disposal of waste and recovered materials.	None.	**Required**
MA 1	**BUILDING REUSE**	1 credit for the reuse of 30% or more of existing sub-structure or shell. 2 credits for the reuse of 60% or more of existing sub-structure or shell. 1 additional BONUS credit for use of 90% or more of existing sub-structure or shell.	Buildings on reclaimed land or Greenfield sites.	**2** **1B**
MA 2	**MODULAR AND STANDARDISED DESIGN**	1 credit for demonstrating the application of modular and standardised design.	None.	**1**
MA 3	**PREFABRICATION**	1 credit when the manufacture of 20% of listed prefabricated building elements has been off-site. 2 credits where the manufacture of 40% of listed prefabricated building elements has been off-site.	None.	**2**
MA 4	**ADAPTABILITY AND DECONSTRUCTION**	1 credit for designs providing spatial flexibility that can adapt spaces for different uses, and allows for expansion to permit additional spatial requirements to be accommodated. 1 credit for flexible design of services that can adapt to changes of layout and use. 1 credit for designs providing flexibility through the choice of building structural system that allows for change in future use, and which is coordinated with interior planning modules.	None.	**1** **1** **1**
MA 5	**RAPIDLY RENEWABLE MATERIALS**	1 credit for demonstrating 2.5% of all building materials/products used in the project are rapidly renewable materials. 2 credits where 5% of all building materials/products used in the project are rapidly renewable materials.	None.	**2**
MA 6	**SUSTAINABLE FOREST PRODUCTS**	1 credit for demonstrating at least 50% of all timber and composite timber products used in the project are from sustainable sources/recycled timber.	None.	**1**

MA 7	RECYCLED MATERIALS	1 credit for use of recycled materials contributing to at least 10% of all materials used in site exterior surfacing work, structures and features.	None.	1
		1 credit where at least 10% of all building materials used for facade and structural components are recycled materials.		1
		1 credit where at least 10% of all building materials used for interior non-structural components are recycled materials		1
MA 8	OZONE DEPLETING SUBSTANCES	1 credit for the use of refrigerants with a value less than or equal to the threshold of the combined contribution to zone depletion and global warming potentials using the specified equation.	None.	1
		1 credit for the use of products in the building fabric and services that avoids the use of ozone depleting substances in their manufacture, composition or use.		1
MA 9	REGIONALLY MANUFACTURED MATERIALS	1 credit for the use of materials manufactured locally within 800km from the site, which contribute to at least 10% of all building materials used in the project. 2 credits for the use of materials manufactured locally within 800km from the site, which contribute to at least 20% of all building materials used in the project.	None.	2
MA 10	DEMOLITION WASTE REDUCTION	1 credit for demonstrating that at least 30% of demolition waste is recycled. 2 credits for demonstrating that al least 60% of demolition waste is recycled.	Projects where demolition is not required or is not under the Client's control.	2
MA 11	CONSTRUCTION WASTE REDUCTION	1 credit for demonstrating that at least 30% of construction waste is recycled. 2 credits for demonstration that at least 60% of construction waste is recycled.	None.	2
4	**ENERGY USE (EU)**			**42+2B**
EU P1	MINIMUM ENERGY PERFORMANCE	Demonstrate compliance with the latest edition of Building Energy Codes (BEC).	None.	**Required**
EU 1	REDUCTION OF CO_2 EMISSIONS	For Commercial and Hotel Buildings, 1 to 15 credits for a reduction of CO_2 emissions or annual energy consumption by 3%, 5%, 7%, 9%, 11%, 14%, 17%, 20%, 23%, 26%, 29%, 33%, 37%, 41% and 45% respectively. For Educational Buildings, 1 to 15 credits for reduction of CO_2 emissions or annual energy consumption by 3%, 4%, 5%, 6%, 7%, 9%, 11%, 13%, 15%, 17%, 19%, 21%, 24%, 27% and 30% respectively. For Residential Buildings, 1 to 15 credits for reduction of CO_2 emissions or annual energy consumption by 3%, 4%, 5%, 6%, 7%, 8%, 9%, 10%, 11%, 12%, 13%, 14%, 16%, 18% and 20% respectively. For Other Building Types, 1 to 15 credits for reduction of CO_2 emissions or annual energy consumption by 1%, 2%, 3%, 4%, 5%, 6%, 7%, 8%, 9%, 10%, 12%, 14%, 16%, 18% and 20% respectively.	None.	15
EU 1	OPTION 2 ALTERNATIVE ROUTE: PASSIVE DESIGN	Note: if this route is followed the following credits, as they are covered in the alternative route, are excluded from the assessment: Eu 1 Reduction of CO_2 Emissions Eu 2 Peak Electricity Demand Reduction Eu 13 Energy Efficient Building Layout The following credits are available for optimised design in: Site planning and building orientation – Up to 3 credits. Envelope heat transfer – Up to 5 credits. Natural ventilation – Up to 5 credits. Daylight design– 1 credits. Common area servicing– Up to 6 credits.	None.	20
EU 2	PEAK ELECTRICITY DEMAND REDUCTION	For Commercial and Hotel Buildings, 1 to 3 credits for a reduction in the peak electricity demand by 15%, 23% and 30% respectively. For Educational and Residential Buildings, 1 to 3 credits for a reduction in the peak electricity demand by 8%, 12% and 15% respectively. For Other Building Types, 1 to 3 credits for a reduction in the peak electricity demand by 8%, 12% and 15% respectively.	None.	3

Eu 3	**Embodied Energy in Building Structural Elements**	1 credit for demonstrating the embodied energy in the major elements of the building structure of the assessed building has been studied through a Life Cycle Assessment (LCA). 1 BONUS credit for demonstrating the major materials with low embodied energy are used in the project utilizing the LCA results.	None.	**1** **1B**
Eu 4	**Ventilation Systems in Car Parks**	1 credit for ventilation systems that will consume less electricity than those meeting the zero credit requirements (baseline) by 20% or more. 2 credits where the consumption is reduced by 25% or more.	Buildings without carpark or carpark area less than 10% CFA.	**2**
Eu 5	**Lighting System in Car Parks**	1 credit for using lamps and, where applicable, ballasts that will consume less electricity than those meeting the zero-credit requirements by 20% or more. 2 credits where the consumption is reduced by 25% or more.	Buildings without carpark or carpark area less than 10% CFA.	**2**
Eu 6	**Renewable Energy Systems**	1 to 5 credits where 0.5% to 2.5% or more of building energy consumption is obtained from renewable energy sources. Alternatively, 1 to 5 credits where the minimum percentage of 20% to 100% of the building footprint is being covered/used by PV panels respectively and/or other renewable power facility generation equivalent renewable power output.	None.	**5**
Eu 7	**Air-conditioning Units**	1 credit for complying with the recommended installation positions for air-conditioning units with regard to internal spaces; complying with the minimum width of any external recess with regard to heat rejection; and complying with the items listed in the assessment checklist.	Buildings not using window and/or split-type air-conditioners.	**1**
Eu 8	**Clothes Drying Facilities**	1 credit for providing suitable clothes drying facilities which utilise the natural environment for all residential units.	Buildings other than residential buildings.	**1**
Eu 9	**Energy Efficient Appliances**	1 credit when 60% of total rated power of appliances and equipment are certified energy efficient products. 2 credits when 80% of total rated power of appliances and equipment are certified energy efficient products.	Buildings where appliances are not provided by the developer.	**2**
Eu 10	**Testing and Commissioning**	1 credit for provision of appropriate specifications and cost provisions in contract documents detailing the commissioning requirements for all systems and equipment that impact on energy use and indoor environmental quality. 1 credit for the appointment of a commissioning authority and provision of a detailed commissioning plan that embraces all specified commissioning work. 1 credit for ensuring full and complete commissioning of all systems, equipment and components that impact on energy use and indoor environmental quality. 1 credit for providing fully detailed commissioning reports for all systems, equipment and components that impact on energy use and indoor environmental quality. 1 BOUNS credit for engagement of an independent commissioning authority in the Testing and Commissioning process.	None.	**1** **1** **1** **1** **1B**
Eu 11	**Operation and Maintenance**	1 credit for providing a fully documented operations and maintenance manual to the minimum specified. 1 credit for providing fully documented instructions that enable systems to operate at a high level of energy efficiency. 1 credit for providing training for operations and maintenance staff to the minimum specified; and demonstrating that adequate maintenance facilities are provided for operations and maintenance work.	None.	**1** **1** **1**
Eu 12	**Metering and Monitoring**	1 credit for installation of: metering that allows monitoring of electricity use by the main chiller plant and auxiliaries; instruments for monitoring building cooling load and operating parameters of the central chiller plant; metering that allows separate monitoring of electricity use by the air side of the HVAC system; and metering for landlord's electricity consumption in common space/public areas.	None.	**1**
Eu 13	**Energy Efficient Building Layout**	1 credit for demonstrating the fulfillment of at least 3 items out of the following strategies. 2 credits for demonstrating the fulfillment of all of the following strategies. For all building types excluding residential a) Consideration of built form and building orientation to enhance energy conservation; b) Consideration of optimum spatial planning to enhance energy conservation; c) Consideration of building permeability provisions of building features to	None.	**2**

		enhance the use of natural ventilation; d) Provision of fixed or movable horizontal/vertical external shading devices; and e) Provision of movable external shading devices for major atrium facade windows or skylights. For residential developments a) To demonstrate compliance, energy simulation must be provided to show that the average solar irradiance of all facades is lower than 395 kW/m^2. b) Compliance is demonstrated by showing that a site permeability of 20% can be achieved between assessed building and nearby buildings/obstructions. c) Demonstrate that 20% of the habitable space can utilise natural ventilation either by the prescriptive approach or the performance approach. d) Demonstrate that the OTTV of habitable spaces is less than or equal to 30 W/m^2. e) Demonstrate that the VDF of habitable spaces are 50% more than the baseline requirements.		
5	**WATER USE (WU)**			**9+1B**
WU P1	**WATER QUALITY SURVEY**	Demonstrate that the quality of potable water meets the referenced drinking water quality standards at all points of use.	None.	**Required**
WU P2	**MINIMUM WATER SAVING PERFORMANCE**	Demonstrate that the use of water efficient devices leads to an estimated aggregate annual saving of 10%.	None.	**Required**
WU 1	**ANNUAL WATER USE**	1 credit for demonstrating that the use of water efficient devices leads to an estimated aggregate annual saving of 20%. 2 credits for demonstrating an estimated annual saving of 25%. 3 credits for demonstrating an estimated annual saving of 30%.	None.	**3**
WU 2	**MONITORING AND CONTROL**	1 credit for installation of devices to monitor water leakage from the fresh water distribution systems without embedded plumbing pipework.	None.	**1**
WU 3	**WATER EFFICIENT IRRIGATION**	1 credit for the use of an irrigation system which does not require the use of municipal fresh water after a period of establishment is complete. Alternatively, 1 credit for demonstrating highly efficient irrigation technology and/or the use of harvested rainwater and/or recycled grey water to reduce fresh water consumption for irrigation by 50% or more in comparison with conventional irrigation of water intensive planting.	Where soft landscaping and planting coverage is less than 50% of the area of the building footprint.	**1**
WU 4	**WATER RECYCLING**	1 credit for harvesting of rainwater which will lead to a reduction of 5% or more in the consumption of fresh water. 1 credit where recycled grey water will lead to a reduction of 5% or more in the consumption of fresh water. 1 BONUS credit where harvesting and/or recycling leads to a reduction of 10% or more in the consumption of fresh water.	None.	**1** **1** **1B**
WU 5	**WATER EFFICIENT APPLIANCES**	1 credit for installing water efficient appliances that have Water Efficiency Labeling Scheme Grade 2 or above.	Buildings in which facilities and/or devices are not installed by the developer.	**1**
WU 6	**EFFLUENT DISCHARGE TO FOUL SEWERS**	1 credit for demonstrating an estimated reduction in annual sewage volumes by 20% or more.	None.	**1**
6	**INDOOR ENVIRONMENTAL QUALITY (IEQ)**			**32+3B**
IEQ P1	**MINIMUM VENTILATION PERFORMANCE**	Demonstrate that the project is in compliance with the minimum requirements of ASHRAE 62.1-2007 in respect of Outdoor Air Quality and Minimum Ventilation Rate.	Residential and similar buildings without central air conditioning.	**Required**
IEQ 1	**SECURITY**	1 credit for scoring at least 75%of the applicable security measures and facilities for the building.	None.	**1**
IEQ 2	**PLUMBING AND DRAINAGE**	1 credit for designs that reduce the potential for transmission of harmful bacteria viruses, and odours.	None.	**1**
IEQ 3	**BIOLOGICAL CONTAMINATION**	1 credit for complying with the recommendations given in the Code of Practice - Prevention of Legionnaires Disease, in respect of air-conditioning and ventilation and water systems.	Residential buildings.	**1**
IEQ 4	**WASTE DISPOSAL FACILITIES**	1 credit for the provision of a de-odourising system in all refuse collection rooms and chambers.	None.	**1**

IEQ 5	**CONSTRUCTION IAQ MANAGEMENT**	1 credit for implementing a Construction IAQ Management Plan. 1 credit for undertaking a building 'flush out' or 'bake out'; and replacement of all filters prior to occupancy.	Residential and similar buildings not provided with central air-conditioning and ventilation systems.	**1** **1**
IEQ 6	**OUTDOOR SOURCES OF AIR POLLUTION**	1 credit for demonstrating compliance with appropriate criteria for carbon monoxide, nitrogen dioxide and ozone. 1 credit for demonstrating compliance with the appropriate criteria for RSP.	Buildings that are designed for natural ventilation or using de-centralised A/C system.	**1** **1**
IEQ 7	**INDOOR SOURCES OF AIR POLLUTION**	1 credit for demonstrating compliance with the appropriate criteria for volatile organic compounds. 1 credit for demonstrating compliance with the appropriate criteria for formaldehyde. 1 credit for demonstrating compliance with the appropriate criteria for radon.	Items a) & b) are excluded for buildings that are designed for natural ventilation or using de-centralised A/C system and without interior decoration.	**1** **1** **1**
IEQ 8	**IAQ IN CAR PARKS**	1 credit for demonstrating compliance with the design requirements specified in ProPECC PN 2/96.	Buildings with no car park.	**1**
IEQ 9	**INCREASED VENTILATION**	1 credit for demonstrating an outdoor ventilation rate that exceeds ASHRAE 62.1:2007 requirements by at least 30%	Residential and similar buildings without central air conditioning.	**1**
IEQ 10	**BACKGROUND VENTILATION**	1 credit where it can be demonstrated that adequate ventilation can be achieved by natural means.	Buildings not designed to utilise natural ventilation.	**1**
IEQ 11	**LOCALISED VENTILATION**	1 credit for the provision of an adequate ventilation system for rooms/areas where significant indoor pollution sources are generated. 1 credit for the provision of a general exhaust system for future tenants.	2nd credit not applicable to residential and similar buildings.	**1** **1**
IEQ 12	**VENTILATION IN COMMON AREAS**	1 credit for demonstrating that all enclosed common areas in a building are provided with adequate ventilation. 1 BONUS credit where the provision for ventilation is by natural means.	Spaces covered under the section on Localised Ventilation.	**1** **1B**
IEQ 13	**THERMAL COMFORT IN AIR-CONDITIONED PREMISES**	1 credit for sustaining the air temperature at the design value within ±1.5°C when the air side system is operating at steady state under normal occupied periods. 1 credit where room air diffusers satisfy the Air Diffusion Performance Index.	Premises where air-conditioning is provided by window units or split units.	**1** **1**
IEQ 14	**THERMAL COMFORT IN NATURALLY VENTILATED PREMISES**	1 credit for demonstrating indoor operative temperatures in occupied/habitable rooms meet the 80% acceptability limits. Alternatively, 1 credit for demonstrating the predicted Mean Vote (PMV) in occupied/habitable rooms is between –1 and +1. Alternatively, 1 credit for demonstrating that, the thermal performance, and the internal wind speeds, of the occupied/habitable rooms fall within the 80% acceptability range for the tropical climate conditions of Hong Kong. 1 credit for sustaining the air temperature at the design value within ±1.5°C when the air-conditioning unit is operating at steady state under normal occupied periods.	Buildings that are not designed to utilise natural ventilation.	**1** **1**
IEQ 15	**NATURAL LIGHTING**	1 credit where at least 80% of the floor area in all normally occupied spaces is adequately lit with an average daylight factor of 1%. 2 credits where at least 95% of the floor area in all normally occupied spaces is adequately lit with an average daylight factor of 1%.	None.	**1** **1**
IEQ 16	**INTERIOR LIGHTING IN NORMALLY OCCUPIED AREAS**	1 credit where the prescribed lighting performance in each type of premises in respect of illuminance and lighting quality is achieved. It is required to fulfill (i) prescribed lighting performance in respect of maintained illuminance and illumance variation; and (ii) the limiting unified glare rating is achieved and light sources have an appropriate colour rendering index. 1 BONUS credit for providing automatic control of artificial lighting such as daylight sensors at perimeter zone and/or occupancy sensor.	Residential buildings, hotels and apartment buildings.	**1** **1B**
IEQ 17	**INTERIOR LIGHTING IN AREAS NOT NORMALLY OCCUPIED**	1 credit where the prescribed lighting performance in each type of common or service space in respect of light output and lighting quality is achieved.	None.	**1**
IEQ 18	**ROOM ACOUSTICS**	1 credit for demonstrating that intruding noise levels are within the prescribed criteria and the mid-frequency reverberation time in applicable rooms meets the prescribed criteria for give types of premises.	Buildings/premises where speech intelligibility is not important, and rooms of	**1**

		Based on the nature of the building, relaxation should be allowed in considering the acceptance of this credit. The applicant should provide full submission of the design and calculation to justify the relaxation.	a special acoustical nature.	
IEQ 19	**NOISE ISOLATION**	1 credit for demonstrating airborne noise isolation between rooms, spaces and premises meets the prescribed criteria. For residential developments only, 1 BONUS credit for demonstrating impact noise isolation between floors meets the prescribed criteria. Based on the nature of the building, relaxation should be allowed in considering the acceptance of this credit. The applicant should provide full submission of the design and calculation to justify the relaxation.	Buildings/premises which are inherently noisy and unaffected by noise.	**1** **1B**
IEQ 20	**BACKGROUND NOISE**	1 credit for demonstrating background noise levels are within the prescribed criteria. Based on the nature of the building, relaxation should be allowed in considering the acceptance of this credit. The applicant should provide full submission of the design and calculation to justify the relaxation.	Buildings/premises in which speech intelligibility is not important.	**1**
IEQ 21	**INDOOR VIBRATION**	1 credit for demonstrating vibration levels shall not exceed the prescribed criteria. Based on the nature of the building, relaxation should be allowed in considering the acceptance of this credit. The applicant should provide full submission of the design and calculation to justify the relaxation.	None.	**1**
IEQ 22	**ACCESS FOR PERSONS WITH DISABILITY**	1 credit for providing at least 3 enhanced provisions	None.	**1**
IEQ 23	**AMENITY FEATURES**	1 credit for providing at least 3 amenity features that enhance the quality and functionality of a building to the benefit of building users 1 credit for providing at least 3 amenity features that allow for improved operation and maintenance of the building and its engineering services.	None.	**1** **1**
7	**INNOVATIONS AND ADDITIONS (IA)**			**5B+1**
IA 1	**INNOVATIVE TECHNIQUES**	Maximum 5 BONUS credits + 1 credit for BEAM Professional	NA.	**5B+1**
IA 2	**PERFORMANCE ENHANCEMENTS**		NA.	
IA 3	**BEAM PROFESSIONAL**			

Note: B denotes Bonus Credit.

Appendix C - Revised Credits Comparison for New buildings

	Version 1.1	Version 1.2
SA5 Ecological Impact	1 BONUS credit for meeting a value less than 30% of score obtained in Habitat Section of Nature Outlook Assessment and for meeting a value less than 20% of score obtained in Biodiversity Section of Nature Outlook, or demonstrating that appropriate design measures have been implemented to contribute positively to the ecological value of the site.	1 BONUS credit from SA 5 Ecological Impact can be achieved through the following: Having a site which scores less than 20% of the points in the Habitat Section of The Nature Conservation Policy – 2009 and having a site which scores less than 30% in the Biodiversity Section of The Nature Conservation Policy - 2009; or Demonstrating that appropriate design measures have been implemented to contribute positively to the ecological value of the site
SA 8 Microclimate Around Buildings	1 credit for demonstrating that no pedestrian areas will be subject to excessive wind velocities caused by amplification due to the site layout and/or building design.	1 credit for demonstrating that no pedestrian areas will be subject to excessive wind velocities caused by amplification due to the site layout design and/or building design.
	1 credit for providing shade on at least 50% of non-roof impervious surfaces on the site (parking, walkways, plazas) using light coloured high-albedo materials (reflectance of at least 0.3)	1 credit for providing shade on at least 50% of non-roof impervious surfaces on the site (parking, walkways, plazas) using light coloured high-albedo materials (albedo of at least 0.4).
	1 credit for providing high emissivity roofing (emissivity of at least 0.9) material or vegetation roof covering at least 50% of the total roof area.	1 credit for providing roof material that meets the Solar Reflectance Index (SRI) of 78 or vegetation roof covering at least 50% of the total roof area.
	1 credit for conducting an Air Ventilation Assessment (AVA) by wind tunnel or CFD according to the methodology introduced by HPLB & ETWB in 2006 and demonstrating the best building	1 credit for conducting an AVA by wind tunnel or Computational Fluid Dynamics (CFD) according to the prevailing AVA methodology introduced by the Government demonstrating the optimal option is

	design option is adopted in comparing with different options.	selected in comparing with different options.
EU1 Reduction of CO2 Emissions	For Commercial and Hotel Buildings, 1 to 15 credits for a reduction of CO2 emissions or annual energy consumption by 3%, 5%, 7%, 9%, 11%, 14%, 17%, 20%, 23%, 26%, 29%, 33%, 37%, 41% and 45% respectively.	For Commercial and Hotel Buildings, 1 to 15 credits for a reduction of CO2 emissions or annual energy consumption by 3%, 5%, 7%, 9%, 11%, 14%, 17%, 20%, 23%, 26%, 29%, 33%, 37%, 41% and 45% respectively.
	For Educational Buildings, 1 to 15 credits for reduction of CO2 emissions or annual energy consumption by 3%, 4%, 5%, 6%, 7%, 9%, 11%, 13%, 15%, 17%, 19%, 21%, 24%, 27% and 30% respectively.	For Educational Buildings, 1 to 15 credits for reduction of CO2 emissions or annual energy consumption by 3%, 4%, 5%, 6%, 7%, 9%, 11%, 13%, 15%, 17%, 19%, 21%, 24%, 27% and 30% respectively.
	For Residential Buildings, 1 to 15 credits for reduction of CO2 emissions or annual energy consumption by 3%, 4%, 5%, 6%, 7%, 8%, 9%, 10%, 11%, 12%, 13%, 14%, 16%, 18% and 20% respectively.	For Residential Buildings, 1 to 15 credits for reduction of CO2 emissions or annual energy consumption by 3%, 4%, 5%, 6%, 7%, 8%, 9%, 10%, 11%, 12%, 13%, 14%, 16%, 18% and 20% respectively.
	For All Building Types using Performance-based BEC method, 1 to 15 credits for reduction of CO2 emissions or annual energy consumption by 1%, 2%, 3%, 4%, 5%, 6%, 7%, 8%, 9%, 10%, 12%, 14%, 16%, 18% and 20% respectively.	For Other Building Types, 1 to 15 credits for reduction of CO2 emissions or annual energy consumption by 1%, 2%, 3%, 4%, 5%, 6%, 7%, 8%, 9%, 10%, 12%, 14%, 16%, 18% and 20% respectively.
EU1 Option 2 Alternative Route: Passive Design		Note: if this route is followed the following credits, as they are covered in the alternative route, are excluded from the assessment:
		EU1 Reduction of CO2 Emissions
		EU2 Peak Electricity Demand Reduction
		EU13 Energy Efficient Building Layout

		The following credits are available for optimised design in: Site planning and building orientation – Up to 3 credits. Envelope heat transfer – Up to 5 credits. Natural ventilation – Up to 5 credits. Daylight design– 1 credits. Common area servicing– Up to 6 credits.
EU2 Peak Electricity Demand Reduction	For Commercial and Hotel Buildings, 1 to 3 credits for a reduction in the maximum electricity demand by 15%, 23% and 30% respectively.	For Commercial and Hotel Buildings, 1 to 3 credits for a reduction in the peak electricity demand by 15%, 23% and 30% respectively.
	For Educational and Residential Buildings, 1 to 3 credits for a reduction in the maximum electricity demand by 8%, 12% and 15% respectively.	For Educational and Residential Buildings, 1 to 3 credits for a reduction in the peak electricity demand by 8%, 12% and 15% respectively.
		For Other Building Types, 1 to 3 credits for a reduction in the peak electricity demand by 8%, 12% and 15% respectively.
EU13 Energy Efficient Building Layout	1 credit for demonstrating the fulfillment of at least 3 items out of the following strategies.	1 credit for demonstrating the fulfillment of at least 3 items out of the following strategies.
	2 credits for demonstrating the fulfillment of all of the following strategies.	2 credits for demonstrating the fulfillment of all of the following strategies.
	(a) Consideration of built form and building orientation to enhance energy conservation;	For all building types excluding residential
		a) Consideration of built form and building orientation to enhance energy conservation;
	(b) Consideration of optimum spatial planning to enhance energy conservation;	b) Consideration of optimum spatial planning to enhance energy conservation;
	(c) Consideration of building permeability provisions of building features to enhance the use of natural ventilation;	c) Consideration of building permeability provisions of building features to enhance the use of natural ventilation;
	(d) Provision of fixed or movable horizontal/vertical external shading	d) Provision of fixed or movable horizontal/vertical external shading

	devices;	devices;
	(e) Provision of movable external shading devices for major atrium facade windows or skylights	e) Provision of movable external shading devices for major atrium facade windows or skylights.
		For residential developments
		a) To demonstrate compliance, energy simulation must be provided to show that the average solar irradiance of all facades is lower than 395 kW/m2.
		b) Compliance is demonstrated by showing that a site permeability of 20% can be achieved between assessed building and nearby buildings/obstructions.
		c) Demonstrate that 20% of the habitable space can utilise natural ventilation either by the prescriptive approach or the performance approach.
		d) Demonstrate that the OTTV of habitable spaces is less than or equal to 30 W/m2.
		e) Demonstrate that the VDF of habitable spaces are 50% more than the baseline requirements.
WU5 Water Efficient Appliances	1 credit for installing water efficient appliances that are at least 20% more efficient than otherwise.	1 credit for installing water efficient appliances that have Water Efficiency Labeling Scheme Grade 2 or above.
	Exclusion: Buildings in which facilities and/or devices are not installed by the developer.	Buildings in which facilities and/or devices are not installed by the developer.
IEQ4 Waste Disposal Facilties	1 credit for the provision of a hygienic refuse collection system.	1 credit for the provision of a de-odourising system in all refuse collection rooms and chambers.
IEQ7 Indoor Sources of Air Pollution	1 credit for demonstrating compliance with the appropriate creteria for VOCs.	1 credit for demonstrating compliance with the appropriate criteria for volatile organic compounds.
	1 credit for demonstrating compliance with the appropriate criteria for formaldehyde.	1 credit for demonstrating compliance with the appropriate criteria for formaldehyde.

	1 credit for demonstrating compliance with the appropriate criteria for radon.	1 credit for demonstrating compliance with the appropriate criteria for radon.
		Exclusion: Items a) & b) are excluded for buildings that are designed for natural ventilation or using de-centralised A/C system and without interior decoration.
IEQ13 Thermal Comfort in Air-Conditioned Premises	1 credit for sustaining the air temperature at the design value within ±1°C when the air side system is operating at steady state under normal occupied periods.	1 credit for sustaining the air temperature at the design value within ±1.5 C when the air side system is operating at steady state under normal occupied periods.
	1 credit where room air diffusers satisfy the Air Diffusion Performance Index	1 credit where room air diffusers satisfy the Air Diffusion Performance Index.
	Exclusion: Premises where air-conditioning is provided by window units or split units.	Exclusion: Premises where air-conditioning is provided by window units or split units.
IEQ14 Thermal Comfort in Naturally Ventilated Premises	1 credit for demonstrating indoor operative temperatures in occupied/habitable rooms meet the 80% acceptability limits.	1 credit for demonstrating indoor operative temperatures in occupied/habitable rooms meet the 80% acceptability limits.
	Alternatively,	Alternatively,
	1 credit for demonstrating the predicted Mean Vote (PMV) in occupied/habitable rooms is between –1 and +1.	1 credit for demonstrating the predicted Mean Vote (PMV) in occupied/habitable rooms is between –1 and +1.
	1 credit for sustaining the air temperature at the design value within ±1.5°C when the air-conditioning unit is operating at steady state under normal occupied periods.	Alternatively,
		1 credit for demonstrating that, the thermal performance, and the internal wind speeds, of the occupied/habitable rooms fall within the 80% acceptability range for the tropical climate conditions of Hong Kong.
		1 credit for sustaining the a temperature at the design value withi ±1.5°C when the air-conditioning unit operating at steady state under norma occupied periods.
	Exclusion: Buildings that are not designed to utilize natural	Exclusion: Buildings that are not designed to utilise

	ventilation.	natural ventilation.
IEQ18 Room Acoustics	1 credit for demonstrating that intruding noise levels are within the prescribed criteria and the mid-frequency reverberation time in applicable rooms meets the prescribed criteria for give types of premises.	1 credit for demonstrating that intruding noise levels are within the prescribed criteria and the mid-frequency reverberation time in applicable rooms meets the prescribed criteria for give types of premises.
		Based on the nature of the building, relaxation should be allowed in considering the acceptance of this credit. The applicant should provide full submission of the design and calculation to justify the relaxation.
	Exclusion: Buildings/premises where speech intelligibility is not important, and rooms of a special acoustical nature.	Exclusion: Buildings/premises where speech 1 intelligibility is not important, and rooms of a special acoustical nature.
IEQ19 Noise Isolation	1 credit for demonstrating airborne noise isolation between rooms, spaces and premises meets the prescribed criteria.	1 credit for demonstrating airborne noise isolation between rooms, spaces and premises meets the prescribed criteria.
	For residential development only, 1 BONUS credit for demonstrating impact noise isolation between floors meets the prescribed criteria.	For residential developments only, 1 BONUS credit for demonstrating impact noise isolation between floors meets the prescribed criteria.
		Based on the nature of the building, relaxation should be allowed in considering the acceptance of this credit. The applicant should provide full submission of the design and calculation to justify the relaxation.
	Exclusion: Buildings/premises which are inherently noisy and unaffected by noise.	Exclusion: Buildings/premises which are inherently noisy and unaffected by noise.
IEQ20 Background Noise	1 credit for demonstrating background noise levels are within the prescribed criteria.	1 credit for demonstrating background noise levels are within the prescribed criteria.

		Based on the nature of the building, relaxation should be allowed in considering the acceptance of this credit. The applicant should provide full submission of the design and calculation to justify the relaxation.
	Exclusion: Buildings/premises in which speech intelligibility is not important.	Exclusion: Buildings/premises in which speech intelligibility is not important.
IEQ21 Indoor Vibration	1 credit for demonstrating vibration levels shall not exceed the prescribed criteria.	1 credit for demonstrating vibration levels shall not exceed the prescribed criteria.
		Based on the nature of the building, relaxation should be allowed in considering the acceptance of this credit. The applicant should provide full submission of the design and calculation to justify the relaxation.
IEQ22 Access For Persons With Disability	1 credit for providing enhanced provisions for access for disabled persons.	1 credit for providing at least 3 enhanced provisions
IEQ23 Amenity Features	1 credit for providing amenity features that enhance the quality and functionality of a building to the benefit of building users.	1 credit for providing at least 3 amenity features that enhance the quality and functionality of a building to the benefit of building users
	1 credit for providing amenity features that allow for improved operation and maintenance of the building and its engineering services.	1 credit for providing at least 3 amenity features that allow for improved operation and maintenance of the building and its engineering services.

Appendix D - Summary of Credits within BEAM Plus V.1.2 for Existing Buildings

	Section:	Credit Requirement:	Exclusions	Credits	Target
2	SITE ASPECTS (SA)			18+1B	
SA P1	ENVIRONMENTALLY PURCHASING PLAN	Demonstrate that environmentally purchasing plan and procedure either following their internal company guideline or other international standards shall be in place.	None.	Required	
SA 1	BEAM CERTIFIED BUILDING	5 credits where the building has been certified with Platinum grade; 4 credits where the building has been certified with Gold grade; or 3 credits where the building has been certified with any other grade. Alternatively, Up to 4 credits for an uncertified building that meets the listed performance characteristics.	None.	5	
SA 2	NOISE FROM BUILDING EQUIPMENT	1 credit for demonstrating that the level of the intruding noise at the facade of the potential noise sensitive receivers is in compliance with the criteria recommended in the Hong Kong Planning Standards and Guidelines.	None.	1	
SA 3	LIGHT POLLUTION	1 credit for demonstrating that obstrusive light from exterior lighting meets the specified performance for the environmental zone in which the building development is located.	None.	1	
SA 4	HEALTH, SAFETY AND ENVIRONMENTAL MANAGEMENT	1 credit where the building management operates an Operational Health and Safety Management System certified to OHSAS 18001 or an Environmental Management System to ISO14001. 1 BONUS credit where both a certified OHSAS and a certified EMS are in place.	None.	1 1B	
SA 5	ENVIRONMENTAL PURCHASING PRACTICES	1 credit for demonstrating 70% of purchased items are environmentally friendly materials, products or equipment for the past 12 months, or equivalent programme for implementation.	None.	1	
SA 6	BUILDING AND SITE OPERATION AND MAINTENANCE	1 credit for implementing an effective system of regular inspection, cleaning and maintenance of the building's fabric and structure. 1 credit for implementing an effective system of regular inspection, cleaning and maintenance of areas and facilities external to the building. 1 credit for providing a fully documented operations and maintenance manual for the building and site to the minimum specified.	Refer to assessment criteria.	1 1 1	
SA 7	BUILDING SERVICES OPERATION AND MAINTENANCE	1 credit for demonstrating the operation of a planned programme of regular inspection, cleaning and maintenance of central HVAC plant. 1 credit for demonstrating the operation of a planned programme of regular inspection, cleaning and maintenance of the building's engineering systems. 1 credit for having undertaken an audit of the effectiveness of the operation and maintenance practices for all building services engineering systems.	None.	1 1 1	
SA 8	STAFFING AND RESOURCES	1 credit for the adequacy of staffing and resources to meet the operation and maintenance requirements of the building.	None.	1	
SA 9	USER GUIDANCE	1 credit for providing comprehensive guidance on building safety, hygiene and environmental issues in a building user's guide.	None.	1	
SA 10	GREEN CLEANING	1 credit for demonstrating appropriate green cleaning procedures/practices are implemented for the project and at least 50% of green cleaning products are used.	None.	1	
3	MATERIALS ASPECTS (MA)			11+2B	
MA P1	USE OF NON-CFC BASED REFRIGERANTS	Using no chlorofluorocarbon (CFC)-based refrigerants in HVAC&R systems.	Building using split-units and/ or window units.	Required	
MA P2	WASTE RECYCLING FACILITIES	Providing facilities for the collection, sorting, storage and disposal of waste and recovered materials.	None.	Required	
MA 1	BUILDING REUSE	1 BONUS credit for the reuse of 30% or more of existing sub-structure or shell.	None.	1B	
MA 2	MODULAR AND STANDARDISED DESIGN	1 credit for demonstrating the use of modular and standardised design.	None.	1	
MA 3	ADAPTABILITY AND DECONSTRUCTION	1 credit for designs providing spatial flexibility that can adapt spaces for different uses. 1 credit for flexible design of services that can adapt to changes of layout and use. 1 BONUS credit for designs providing flexibility through the use of building structural systems that allows for change in future use.	Residential buildings.	1 1 1B	

MA 4	**RAPIDLY RENEWABLE MATERIALS**	1 credit for demonstrating 2.5% of all building materials/products used in the project are rapidly renewable materials. 2 credits where 5% of all building materials /products used in the project are rapidly renewable materials.	None.	**2**
MA 5	**SUSTAINABLE FOREST PRODUCTS**	1 credit for demonstrating at least 50% of all timber and composite timber products used in the project are from sustainable sources/recycled timber.	None.	**1**
MA 6	**OZONE DEPLETING SUBSTANCES**	1 credit for the use of refrigerants with a value less than or equal to the threshold of the combined contribution to ozone depletion and global warming potentials using the specified equation. Alternatively, 1 credit for demonstrating a phased programme of refrigerant replacement together with limitations on leakage.	Buildings using split-units and/or window units.	**1**
		1 credit for the use of products that avoids the use of ozone depleting substances in their manufacture, composition or use.		**1**
		1 credit for undertaking a waste stream audit and developing a waste management system.		**1**
MA 7	**WASTE MANAGEMENT**	1 credit for developing and implementing an environmentally responsive waste management system. 1 credit where the waste management system demonstrates reductions in waste disposal to landfills and increased recycling.	None.	**2**
4	**ENERGY USE (EU)**			**39+2B**
EU P1	**MINIMUM ENERGY PERFORMANCE**	Demonstrate compliance with the Building Energy Codes (BEC).	None.	**Required**
EU 1	**REDUCTION OF CO_2 EMISSIONS**	1 to 15 credits for a reduction of CO_2 emissions or annual energy consumption by 3%, 5%, 7%, 9%, 11%, 14%, 17%, 20%, 23%, 26%, 29%, 33%, 37%, 41% and 45% respectively for Commercial and Hotel Buildings. 1 to 15 credits for reduction of CO_2 emissions or annual energy consumption by 3%, 4%, 5%, 6%, 7%, 9%, 11%, 13%, 15%, 17%, 19%, 21%, 24% and 27% and 30% respectively for Educational Buildings. 1 to 15 credits for reduction of CO_2 emissions or annual energy consumption by 3%, 4%, 5%, 6%, 7%, 8%, 9%, 10%, 11%, 12%, 13%, 14%, 16% and 18% and 20% respectively for Residential Buildings. 1 to 15 credits for reduction of CO_2 emissions or annual energy consumption by 3%, 4%, 5%, 6%, 7%, 8%, 9%, 10%, 11%, 12%, 13%, 14%, 16% and 18% and 20% respectively for other building types,	None.	**15**
		Alternatively, 1 or 2 credits for compliance with the Energy Efficiency codes Up to 4 credits based on energy consumption benchmarks.		**6**
		Alternatively, 1 or 2 credits for compliance with the Energy Efficiency codes. Up to 3 credits for reduced energy use based on billing/metering data.		**5**
EU 2	**PEAK ELECTRICITY DEMAND REDUCTION**	1 to 3 credits for a reduction in the peak electricity demand by 15%, 23% and 30% respectively for Commercial Buildings. 1 to 2 credits for a reduction in the peak electricity demand by 10% and 20% respectively for Hotel Buildings. 1 to 2 credits for a reduction in the peak electricity demand by 8% and 15% respectively for Educational and Residential Buildings. 1 to 3 credits for a reduction in the peak electricity demand by 8%, 12% and 15% respectively.	None.	**3**

		Alternatively, 1 credit for a reduction in electricity maximum demand of 10%, as demonstrated by billing/metering data. 2 credits for a reduction of electricity maximum demand of 20%, as demonstrated by billing/metering data.		**2**
EU 3	**VENTILATION SYSTEMS IN CAR PARKS**	1 credit for ventilation systems that will consume less electricity than those meeting the zero credit requirements (baseline) by 20% or more. 2 credits where the consumption is reduced by 25% or more.	Buildings without carpark or carpark area less than 10% CFA.	**2**
EU 4	**LIGHTING SYSTEM IN CAR PARKS**	1 credit for using lamps and, where applicable, ballasts that will consume less electricity than those meeting the zero-credit requirements by 20% or more. 2 credits where the consumption is reduced by 25% or more.	Buildings without carpark or carpark area less than 10% CFA.	**2**
EU 5	**RENEWABLE ENERGY SYSTEMS**	1 to 5 credits where 0.5% to 2.5% or more of building energy consumption is obtained from renewable energy sources. Alternatively, 1 to 5 credits where the minimum percentage of 20% to 100% of the building footprint is being covered/used by PV panels respectively and/or other renewable power facility generation equivalent renewable power output.	None.	**5**
EU 6	**AIR-CONDITIONING UNITS**	1 credit for complying with the recommended installation positions for air-conditioning units with regard to internal spaces; complying with the minimum width of any external recess with regard to heat rejection; and complying with the items listed in the assessment checklist.	Buildings not using window and/or split-type air-conditioners.	**1**
EU 7	**ENERGY EFFICIENT APPLIANCES**	1 credit when 60% of total rated power of appliances and equipment are certified energy efficient products. 2 credits when 80% of total rated power of appliances and equipment are certified energy efficient products.	Buildings where appliances are not provided by the developer.	**2**
EU 8	**TESTING AND COMMISSIONING**	1 credit for ongoing programme of commissioning of water side equipment of central air-conditioning system. 1 credit for ongoing programme of commissioning of air side equipment of central air-conditioning system.	All 3 credits applicable to buildings with central HVAC services.	**2**
		Alternatively, 1 credit for ongoing programme of commissioning of all HVAC equipment.	For residential and similar buildings only the last 2 credits apply.	**1**
		1 credit for ongoing programme of commissioning of all non-HVAC equipment.		**1**
EU 9	**METERING AND MONITORING**	1 credit for ability to measure and monitor all major electrical loads in the building. 1 additional credit where central chiller plant is provided with adequate instrumentation to determine operating performance.	Residential buildings.	**2**
EU 10	**ENERGY MANAGEMENT**	1 credit for conducting Category 3 energy audit (EMSD's guidelines on Energy Audit) with evidence. 1 BONUS credit for conducting carbon audit or GHG emission audit and demonstrating that an action plan of GHG reduction is in progress.		**1+1B**
		1 credit for an effective energy monitoring and targeting system.	None.	**1**
		1 credit for demonstrating an approved budget to improve the energy performance of the building with management plan.		**1**
		1 credit for maintaining a comprehensive energy management manual.		**1**
		1 BONUS credit where separate charges are made for energy use.		**1B**
5	**WATER USE (WU)**			**7+2B**
WU P1	**WATER QUALITY SURVEY**	Demonstrate that the quality of potable water meets the referenced drinking water quality standards at all points of use.	None.	**Required**
WU P2	**MINIMUM WATER SAVING PERFORMANCE**	Demonstrate that the use of water efficient devices leads to an estimated aggregate annual saving of 10%.	Water consumption in tenancy areas can be excluded.	**Required**
WU P3	**WATER CONSERVATION PLAN**	Develop a water conservation plan endorsed by directorate level management.	None.	**Required**
WU 1	**ANNUAL WATER USE**	1 credit for demonstrating that the use of water efficient devices leads to an estimated aggregate annual saving of 20%. 2 credits for demonstrating an estimated annual saving of 25%. 3 credits for demonstrating an estimated annual saving of 30%.	Water consumption in tenancy areas can be excluded.	**3**
WU 2	**MONITORING AND CONTROL**	1 credit for installation of devices to monitor water leakage within the fresh water distribution system.	None.	**1**
WU 3	**WATER USE FOR IRRIGATION**	1 credit for limited use of fresh water for the purposes of irrigation. Alternately,	Where soft landscaping coverage is less than 50% of the area of the	**1**

		1 credit for demonstrating highly efficient irrigation technology and/or the use of harvested rainwater and/or recycled grey water to reduce fresh water consumption for irrigation by 50% or more in comparison with conventional irrigation of water intensive planting.	building footprint.	
WU 4	**WATER RECYCLING**	1 credit for harvesting rainwater and/or recycling greywater that leads to a reduction of 5% or more in the consumption of fresh water. 1 BONUS credit where harvesting and/or recycling leads to a reduction of 10% or more in the consumption of fresh water.	None.	**1** **1B**
WU 5	**WATER AUDIT**	1 BONUS credit for undertaking a water audit and maintaining a water use inventory.	None.	**1B**
WU 6	**EFFLUENT DISCHARGE TO FOUL SEWERS**	1 credit for demonstrating a reduction in annual sewage volumes by 20% or more, or reduction in sewage concentration by a 30% or more.	None.	**1**
6	**INDOOR ENVIRONMENTAL QUALITY (IEQ)**			**30+3B**
IEQ P1	**MINIMUM VENTILATION PERFORMANCE**	Demonstrate that the project is in compliance with the minimum requirements of ASHRAE 62.1-2007 in respect of Outdoor Air Quality and Minimum Ventilation Rate.	Residential and similar buildings without central air conditioning.	**Required**
IEQ 1	**SECURITY**	1 credit for scoring at least 75% of the applicable security measures and facilities for the building.	None.	**1**
IEQ 2	**PLUMBING AND DRAINAGE**	1 credit where system design, operation and maintenance is such as to reduce the potential for transmission of harmful bacteria viruses, and odours.	None.	**1**
IEQ 3	**BIOLOGICAL CONTAMINATION**	1 credit for complying with the recommendations given in the Code of Practice - Prevention of Legionnaires Disease, in respect of air-conditioning and ventilation systems, and water systems.	Residential buildings.	**1**
IEQ 4	**WASTE DISPOSAL FACILITIES**	1 credit for the provision of a de-odourising system in all refuse collection rooms.	None.	**1**
IEQ 5	**INTEGRATED PEST MANAGMENT**	1 credit for implementing an integrated programme for pest management.	None.	**1**
IEQ 6	**CONSTRUCTION IAQ MANAGEMENT**	1 credit for availability and effective implementation of a Construction IAQ Management.	Residential and similar buildings.	**1**
IEQ 7	**OUTDOOR SOURCES OF AIR POLLUTION**	1 credit for demonstrating compliance with appropriate criteria for Carbon monoxide, Nitrogen dioxide and Ozone.	Buildings that are designed for natural ventilation or using de-centralised a/c system.	**1**
		1 credit for demonstrating compliance with the appropriate criteria for RSP.		**1**
IEQ 8	**INDOOR SOURCES OF AIR POLLUTION**	1 credit for demonstrating compliance with the appropriate criteria for VOCs. 1 credit for demonstrating compliance with the appropriate criteria for formaldehyde. 1 credit for demonstrating compliance with the appropriate criteria for radon.	The first two items are excluded for buildings that are designed for natural ventilation or using de-centralised a/c system.	**1** **1** **1**
IEQ 9	**IAQ IN CAR PARKS**	1 credit for demonstrating compliance with the design requirements specified in ProPECC PN 2/96.	Buildings with no car park.	**1**
IEQ 10	**INCREASED VENTILATION**	1 credit for demonstrating an outdoor ventilation rate that exceeds ASHRAE 62.1:2007 requirements by at least 30%.	Residential and similar buildings without central air conditioning.	**1**
IEQ 11	**BACKGROUND VENTILATION**	1 credit where it can be demonstrated that adequate ventilation is achieved by natural means.	Buildings not designed to utilize natural ventilation.	**1**
IEQ 12	**LOCALISED VENTILATION**	1 credit for the provision of an adequate ventilation system for rooms/areas where significant indoor pollution sources are generated.	None.	**1**
IEQ 13	**VENTILATION IN COMMON AREAS**	1 credit for demonstrating that all enclosed common areas in a building are provided with adequate ventilation. 1 BONUS credit where the provision for ventilation is by natural means.	Spaces covered under the section on Localised Ventilation.	**1** **1B**
IEQ 14	**THERMAL COMFORT IN AIR-CONDITIONED PREMISES**	1 credit for sustaining the air temperature at the design value within ±1.5°C when the air side system is operating at steady state under normal occupied periods. 1 credit where room air diffusers satisfy the Air Diffusion Performance Index.	Premises where air-conditioning is provided by window units or split units.	**1** **1**

IEQ 15	THERMAL COMFORT IN NATURALLY VENTILATED PREMISES	1 credit for demonstrating indoor operative temperatures in occupied/habitable rooms meet the 80% acceptability limits. Alternately, 1 credit for demonstrating the Predicted Mean Vote (PMV) in occupied/habitable rooms is between –1 and +1. 1 credit for sustaining the air temperature at the design value within ±1.5°C when the air-conditioning unit is operating at steady state under normal occupied periods.	Buildings that are not designed to utilize natural ventilation.	1 1
IEQ 16	NATURAL LIGHTING	1 credit where at least 80% of the floor area in all normally occupied spaces is adequately lit with an average daylight factor of 1%. 2 credits where at least 95% of the floor area in all normally occupied spaces is adequately lit with an average daylight factor of 1%.	None.	2
IEQ 17	INTERIOR LIGHTING IN NORMALLY OCCUPIED AREAS	1 credit where the prescribed lighting performance in each type of premises in respect of illuminance and lighting quality is achieved. It is required to fulfill prescribed lighting performance in respect of maintained illuminance and illuminance variation; and the limiting unified glare rating is achieved and light sources have an appropriate colour rendering index. 1 BONUS credit for providing automatic control of artificial lighting such as daylight sensors at perimeter zone and/or occupancy sensor.	Residential buildings, hotels and apartment buildings.	1 1B
IEQ 18	INTERIOR LIGHTING IN AREAS NOT NORMALLY OCCUPIED	1 credit where the prescribed lighting performance in each type of common or service space in respect of light output and lighting quality is achieved.	None.	1
IEQ 19	ROOM ACOUSTICS	1 credit for demonstrating that internal noise levels are within the prescribed criteria and the mid-frequency reverberation time in applicable rooms meets the prescribed criteria for give types of premises. Based on the nature of the building, relaxation should be allowed in considering the acceptance of this credit. The applicant should provide full submission of the design and calculation to justify the relaxation.	Buildings/premises where speech intelligibility is not important, and rooms of a special acoustical nature.	1
IEQ 20	NOISE ISOLATION	1 credit for demonstrating airborne noise isolation between rooms, spaces and premises meets the prescribed criteria. For residential developments only, 1 BONUS credit for demonstrating impact noise isolation between floors meets the prescribed criteria. Based on the nature of the building, relaxation should be allowed in considering the acceptance of this credit. The applicant should provide full submission of the design and calculation to justify the relaxation.	Buildings/premises which are inherently noisy and unaffected by noise.	1 1B
IEQ 21	BACKGROUND NOISE	1 credit for demonstrating background noise levels are within the prescribed criteria. Based on the nature of the building, relaxation should be allowed in considering the acceptance of this credit. The applicant should provide full submission of the design and calculation to justify the relaxation.	Buildings/premises in which speech intelligibility is not important.	1
IEQ 22	ACCESS FOR PERSONS WITH DISABILITY	1 credit for providing at least 3 enhanced provisions	None.	1
IEQ 23	AMENITY FEATURES	1 credit for providing 50% of listed amenity features that enhance the quality and functionality of a building. 2 credits for providing 75% of listed amenity features.	None.	2
7	INNOVATIONS AND ADDITIONS (IA)			5B+1
IA 1	INNOVATIVE TECHNIQUES		Not applicable.	
IA 2	PERFORMANCE ENHANCEMENTS	Maximum 5 BONUS credits + 1 credit for BEAM Professional		5B+1
IA 3	BEAM PROFESSIONAL		Not applicable.	

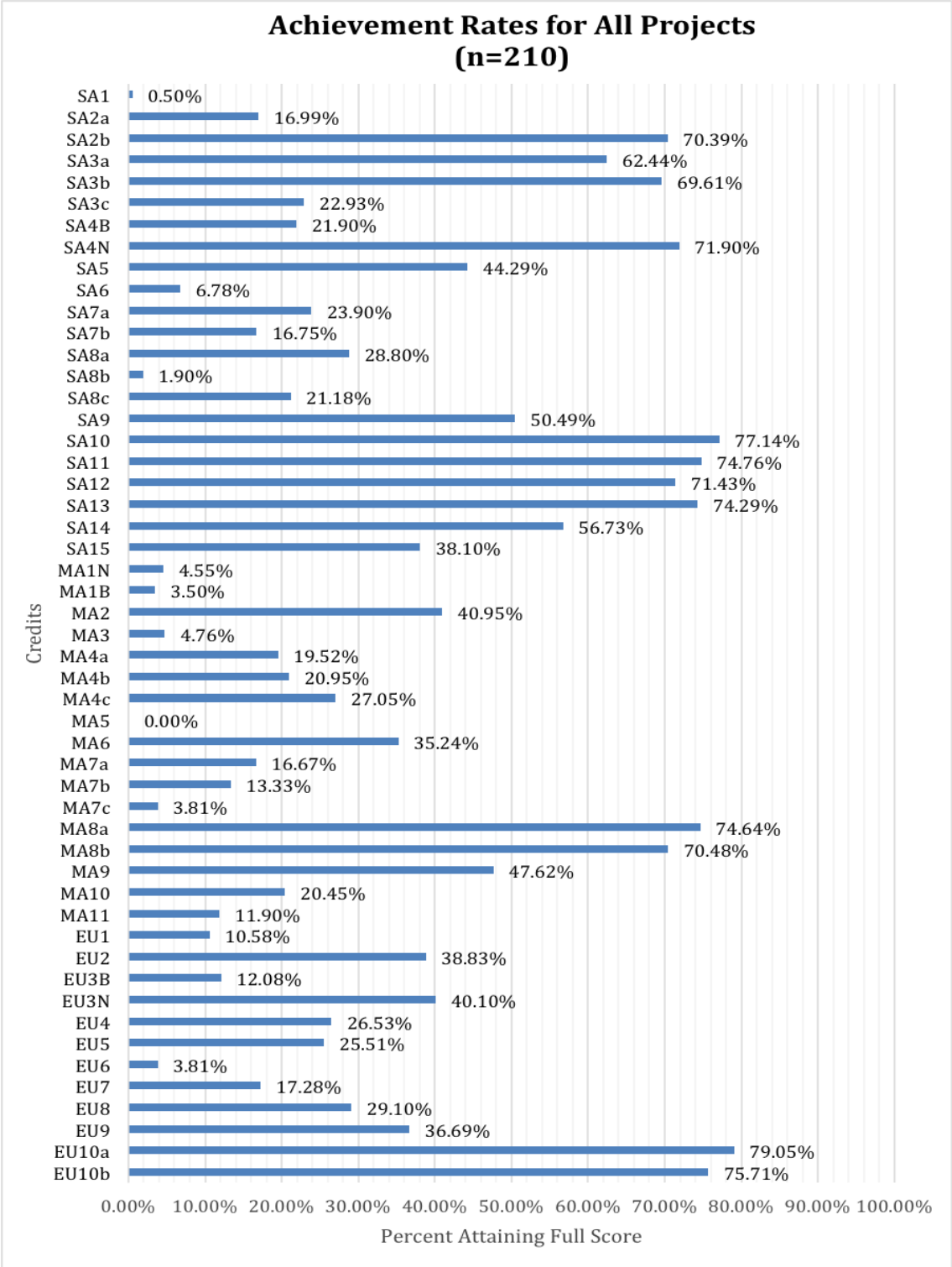
Appendix E - Revised Credits Comparison of BEAM Plus for Existing Building

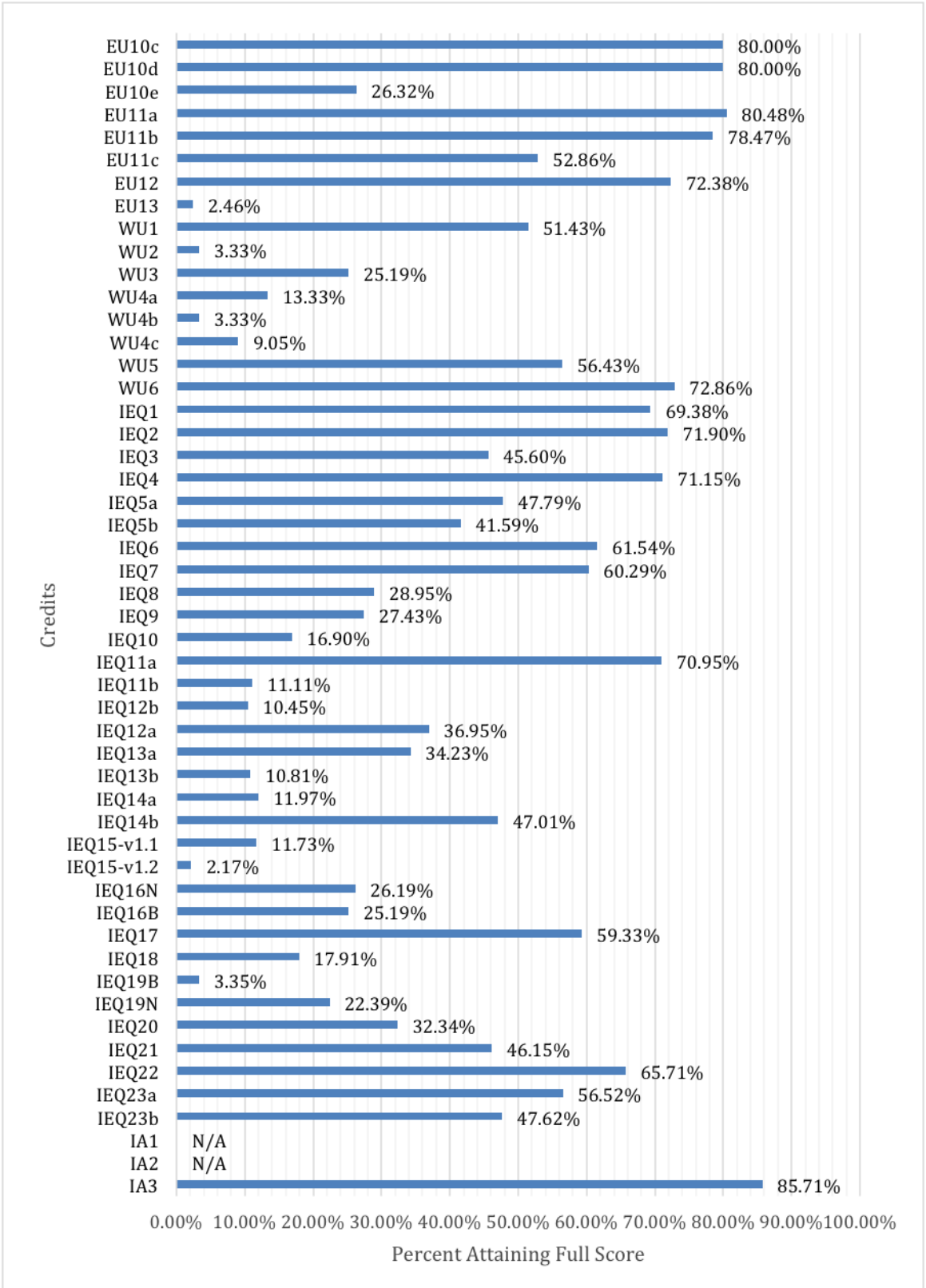
	Version 1.1	Version 1.2
EU2 Peak Electricity Demand Reduction	1 to 3 credits for a reduction in the maximum electricity demand by 15%, 23% and 30% respectively for Commercial Buildings.	1 to 3 credits for a reduction in the peak electricity demand by 15%, 23% and 30% respectively for Commercial Buildings.
	1 to 2 credits for a reduction in the maximum electricity demand by 10% and 20% respectively for Hotel Buildings.	1 to 2 credits for a reduction in the peak electricity demand by 10% and 20% respectively for Hotel Buildings.
	1 to 2 credits for a reduction in the maximum electricity demand by 8% and 15% respectively for Educational and Residential Buildings.	1 to 2 credits for a reduction in the peak electricity demand by 8% and 15% respectively for Educational and Residential Buildings.
		1 to 3 credits for a reduction in the peak electricity demand by 8%, 12% and 15% respectively.
	Alternatively,	Alternatively,
	1 credit for a reduction in electricity maximum demand of 10%, as demonstrated by billing/metering data.	1 credit for a reduction in electricity maximum demand of 10%, as demonstrated by billing/metering data.
	2 credits for a reduction of electricity maximum demand of 20%, as demonstrated by billing/metering data.	2 credits for a reduction of electricity maximum demand of 20%, as demonstrated by billing/metering data.
IEQ4 Waste Disposal Facilities	1 credit for the provision of a hygienic refuse collection system.	1 credit for the provision of a de-odourising system in all refuse collection rooms.
IEQ14 Thermal Comfort in Air-Conditioned Premises	1 credit for sustaining the air temperature at the design value within ±1 C when the air side system is operating at steady state under normal occupied periods.	1 credit for sustaining the air temperature at the design value within ±1.5C when the air side system is operating at steady state under normal occupied periods.

	1 credit where room air diffusers satisfy the Air Diffusion Performance Index.	1 credit where room air diffusers satisfy the Air Diffusion Performance Index.
	Exclusion: Premises where air-conditioning is provided by window units or split units.	Exclusion: Premises where air-conditioning is provided by window units or split units.
IEQ16 Nature Lighting	1 credit where at least 80% of floor area in all normally occupied spaces is adequately lit with an average daylight factor of 2% or more.	1 credit where at least 80% of the floor area in all normally occupied spaces is adequately lit with an average daylight factor of 1%.
	1 credit where provision of suitable daylight glare control and maintaining the average daylight factor of 2%.	2 credits where at least 95% of the floor area in all normally occupied spaces is adequately lit with an average daylight factor of 1%.
IEQ19 Room Acoustics	1 credit for demonstrating that internal noise levels are within the prescribed criteria and the mid-frequency reverberation time in applicable rooms meets the prescribed criteria for give types of premises.	1 credit for demonstrating that internal noise levels are within the prescribed criteria and the mid-frequency reverberation time in applicable rooms meets the prescribed criteria for give types of premises.
		Based on the nature of the building, relaxation should be allowed in considering the acceptance of this credit. The applicant should provide full submission of the design and calculation to justify the relaxation.
	Exclusion: Buildings/premises where speech intelligibility is not 1 important, and rooms of a special acoustical nature.	Exclusion: Buildings/premises where speech intelligibility is not 1 important, and rooms of a special acoustical nature.
IEQ20 Noise Isolation	1 credit for demonstrating airborne noise isolation between rooms, spaces and premises meets the prescribed criteria.	1 credit for demonstrating airborne noise isolation between rooms, spaces and premises meets the prescribed criteria.
	For residential development only, 1 BONUS credit for demonstrating impact noise isolation between floors meets the prescribed criteria.	For residential development only, 1 BONUS credit for demonstrating impact noise isolation between floors meets the prescribed criteria.
		Based on the nature of the building, relaxation should be allowed in considering the acceptance of this credit. The applicant should provide

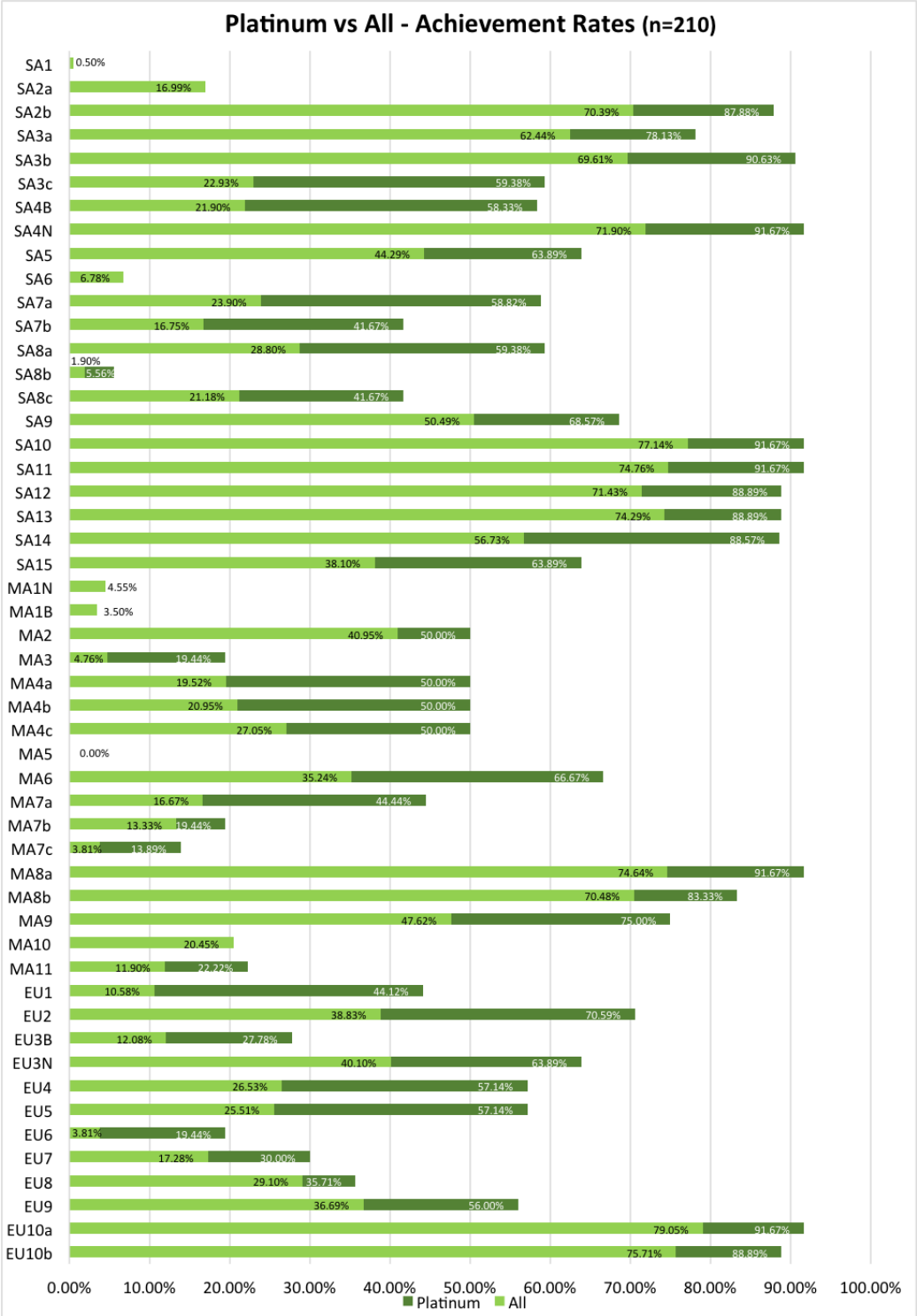
		full submission of the design and calculation to justify the relaxation.
	Exclusion: Buildings/premises which are inherently noisy and unaffected by noise.	Exclusion: Buildings/premises which are inherently noisy and unaffected by noise.
IEQ21 Background Noise	1 credit for demonstrating background noise levels are within the prescribed criteria.	1 credit for demonstrating background noise levels are within the prescribed criteria.
		Based on the nature of the building, relaxation should be allowed in considering the acceptance of this credit. The applicant should provide full submission of thedesign and calculation to justify the relaxation.
	Exclusion: Buildings/premises in which speech intelligibility is not important.	Exclusion: Buildings/premises in which speech intelligibility is not important.
IEQ22 Access for Persons with Disability	1 credit for providing enhanced provisions for access for disabled persons.	1 credit for providing at least 3 enhanced provisions

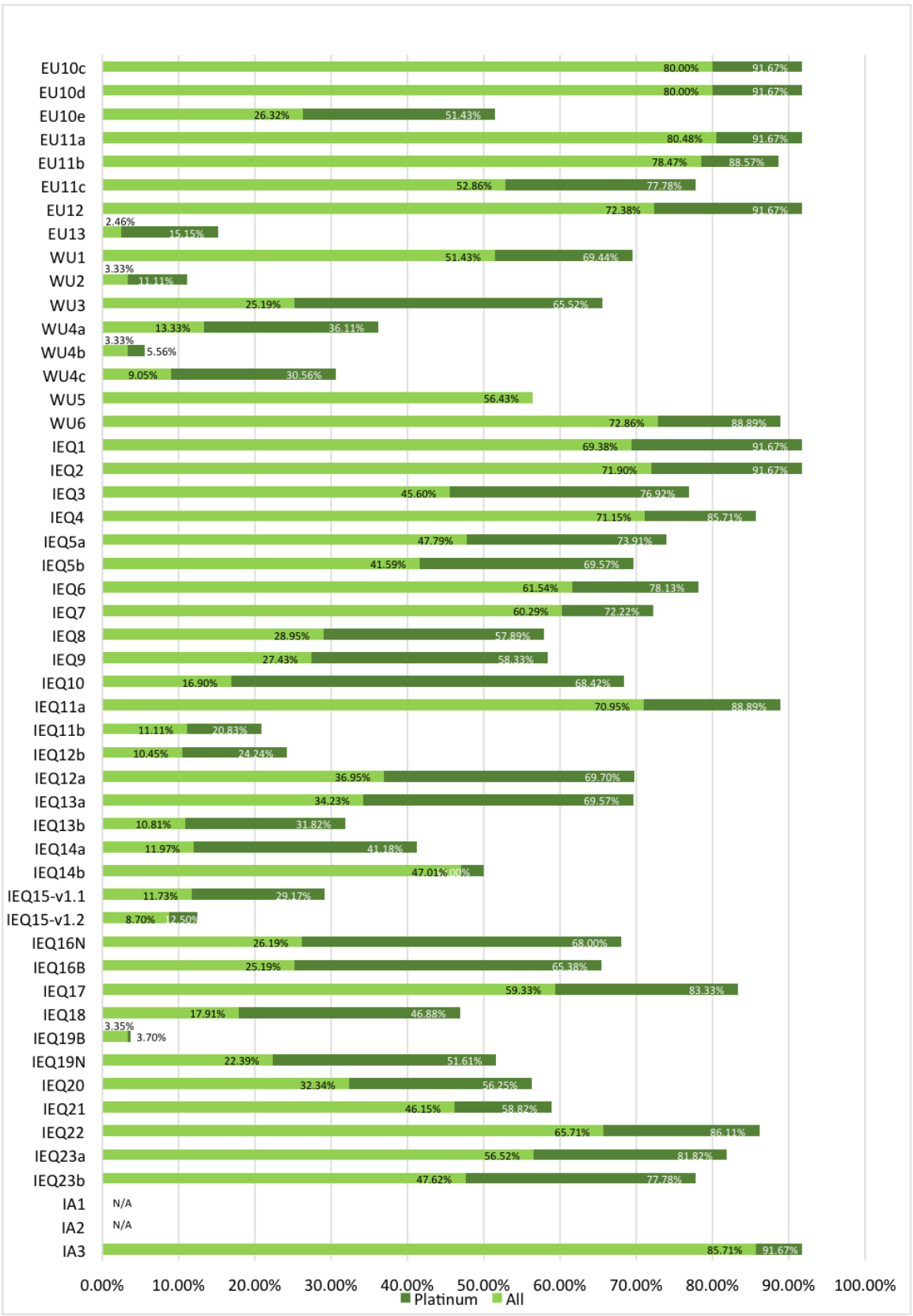
Appendix F: Achievement Rates for All Buildings



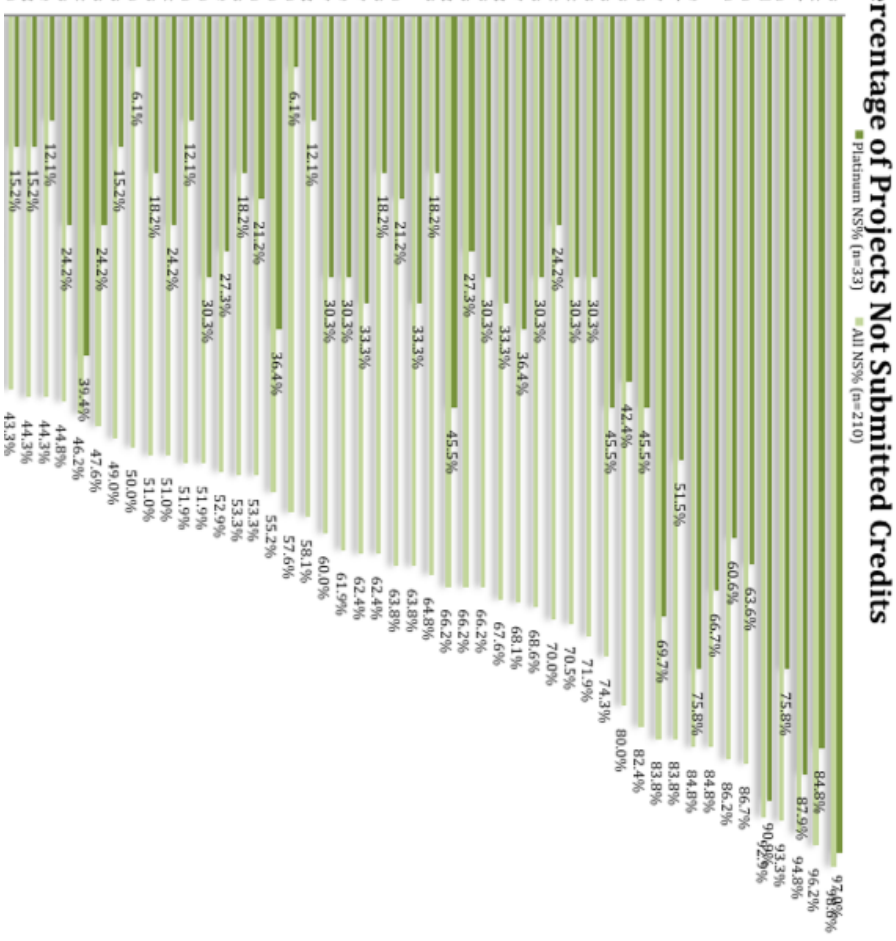

Credits
EU10c 80.00%
EU10d 80.00%
EU10e 26.32%
EU11a 80.48%
EU11b 78.47%
EU11c 52.86%
EU12 72.38%
EU13 2.46%
WU1 51.43%
WU2 3.33%
WU3 25.19%
WU4a 13.33%
WU4b 3.33%
WU4c 9.05%
WU5 56.43%
WU6 72.86%
IEQ1 69.38%
IEQ2 71.90%
IEQ3 45.60%
IEQ4 71.15%
IEQ5a 47.79%
IEQ5b 41.59%
IEQ6 61.54%
IEQ7 60.29%
IEQ8 28.95%
IEQ9 27.43%
IEQ10 16.90%
IEQ11a 70.95%
IEQ11b 11.11%
IEQ12b 10.45%
IEQ12a 36.95%
IEQ13a 34.23%
IEQ13b 10.81%
IEQ14a 11.97%
IEQ14b 47.01%
IEQ15-v1.1 11.73%
IEQ15-v1.2 2.17%
IEQ16N 26.19%
IEQ16B 25.19%
IEQ17 59.33%
IEQ18 17.91%
IEQ19B 3.35%
IEQ19N 22.39%
IEQ20 32.34%
IEQ21 46.15%
IEQ22 65.71%
IEQ23a 56.52%
IEQ23b 47.62%
IA1 N/A
IA2 N/A
IA3 85.71%
0.00% 10.00% 20.00% 30.00% 40.00% 50.00% 60.00% 70.00% 80.00% 90.00% 100.00%
Percent Attaining Full Score

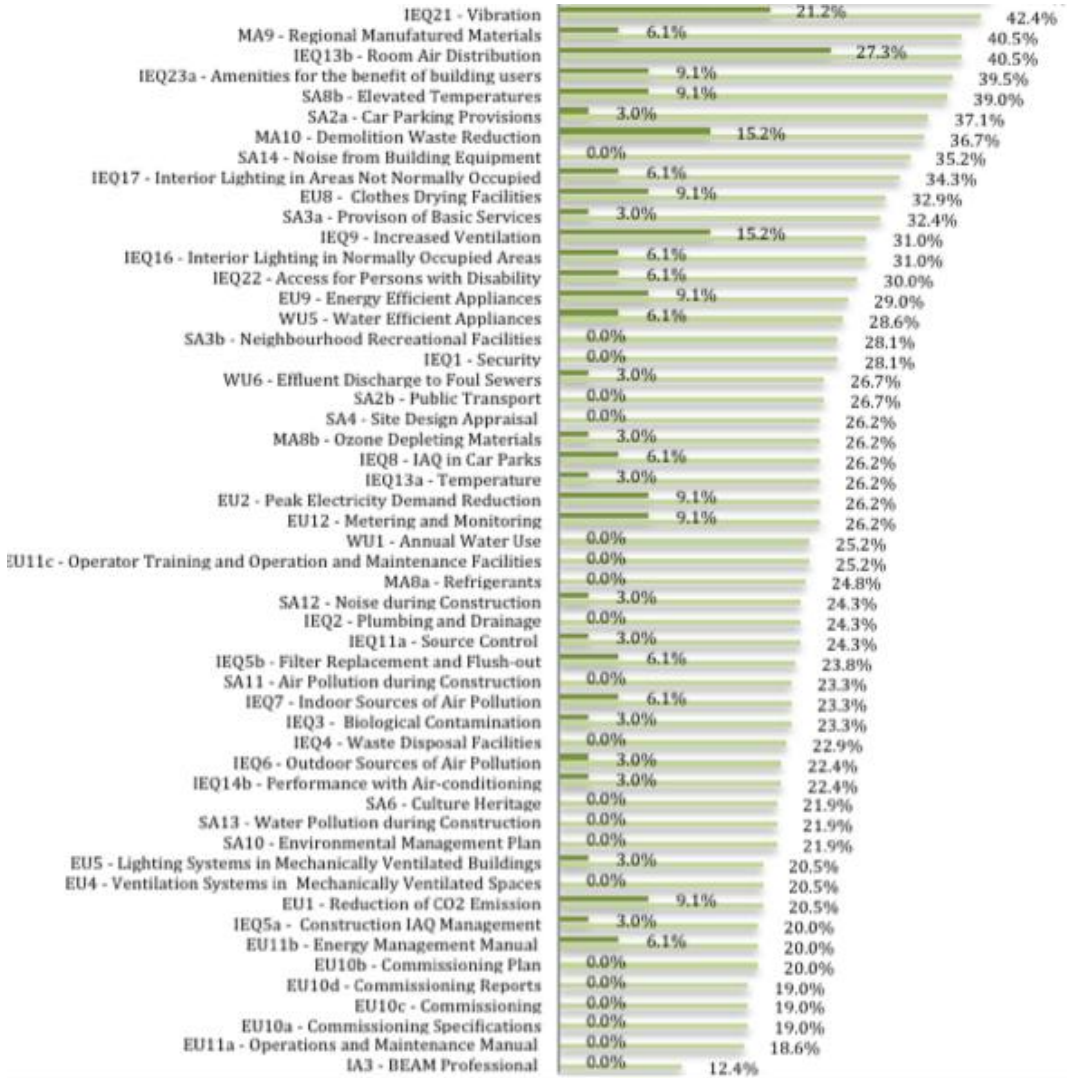
Appendix G: Achievement Rates for All vs. Platinum Projects



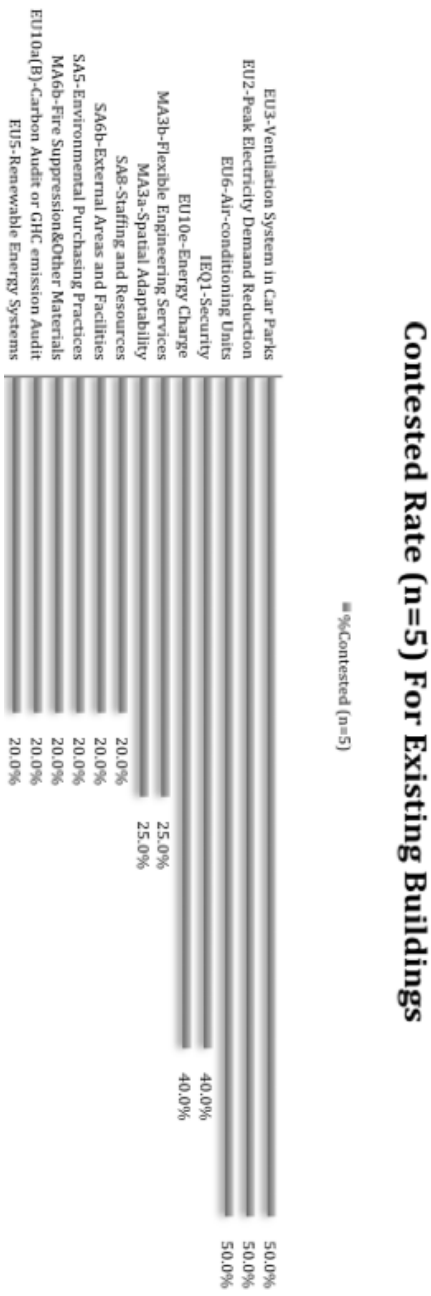

EU10c 80.00% 91.67%
EU10d 80.00% 91.67%
EU10e 26.32% 51.43%
EU11a 80.48% 91.67%
EU11b 78.47% 88.57%
EU11c 52.86% 77.78%
EU12 72.38% 91.67%
EU13 2.46% 15.15%
WU1 51.43% 69.44%
WU2 3.33% 11.11%
WU3 25.19% 65.52%
WU4a 13.33% 36.11%
WU4b 3.33% 5.56%
WU4c 9.05% 30.56%
WU5 56.43%
WU6 72.86% 88.89%
IEQ1 69.38% 91.67%
IEQ2 71.90% 91.67%
IEQ3 45.60% 76.92%
IEQ4 71.15% 85.71%
IEQ5a 47.79% 73.91%
IEQ5b 41.59% 69.57%
IEQ6 61.54% 78.13%
IEQ7 60.29% 72.22%
IEQ8 28.95% 57.89%
IEQ9 27.43% 58.33%
IEQ10 16.90% 68.42%
IEQ11a 70.95% 88.89%
IEQ11b 11.11% 20.83%
IEQ12b 10.45% 24.24%
IEQ12a 36.95% 69.70%
IEQ13a 34.23% 69.57%
IEQ13b 10.81% 31.82%
IEQ14a 11.97% 41.18%
IEQ14b 47.01%
IEQ15-v1.1 11.73% 29.17%
IEQ15-v1.2 8.70% 12.50%
IEQ16N 26.19% 68.00%
IEQ16B 25.19% 65.38%
IEQ17 59.33% 83.33%
IEQ18 17.91% 46.88%
IEQ19B 3.35% 3.70%
IEQ19N 22.39% 51.61%
IEQ20 32.34% 56.25%
IEQ21 46.15% 58.82%
IEQ22 65.71% 86.11%
IEQ23a 56.52% 81.82%
IEQ23b 47.62% 77.78%
IA1 N/A
IA2 N/A
IA3 85.71% 91.67%
0.00% 10.00% 20.00% 30.00% 40.00% 50.00% 60.00% 70.00% 80.00% 90.00% 100.00%
Platinum
All

Appendix H: Not Submitted Rate for New Buildings

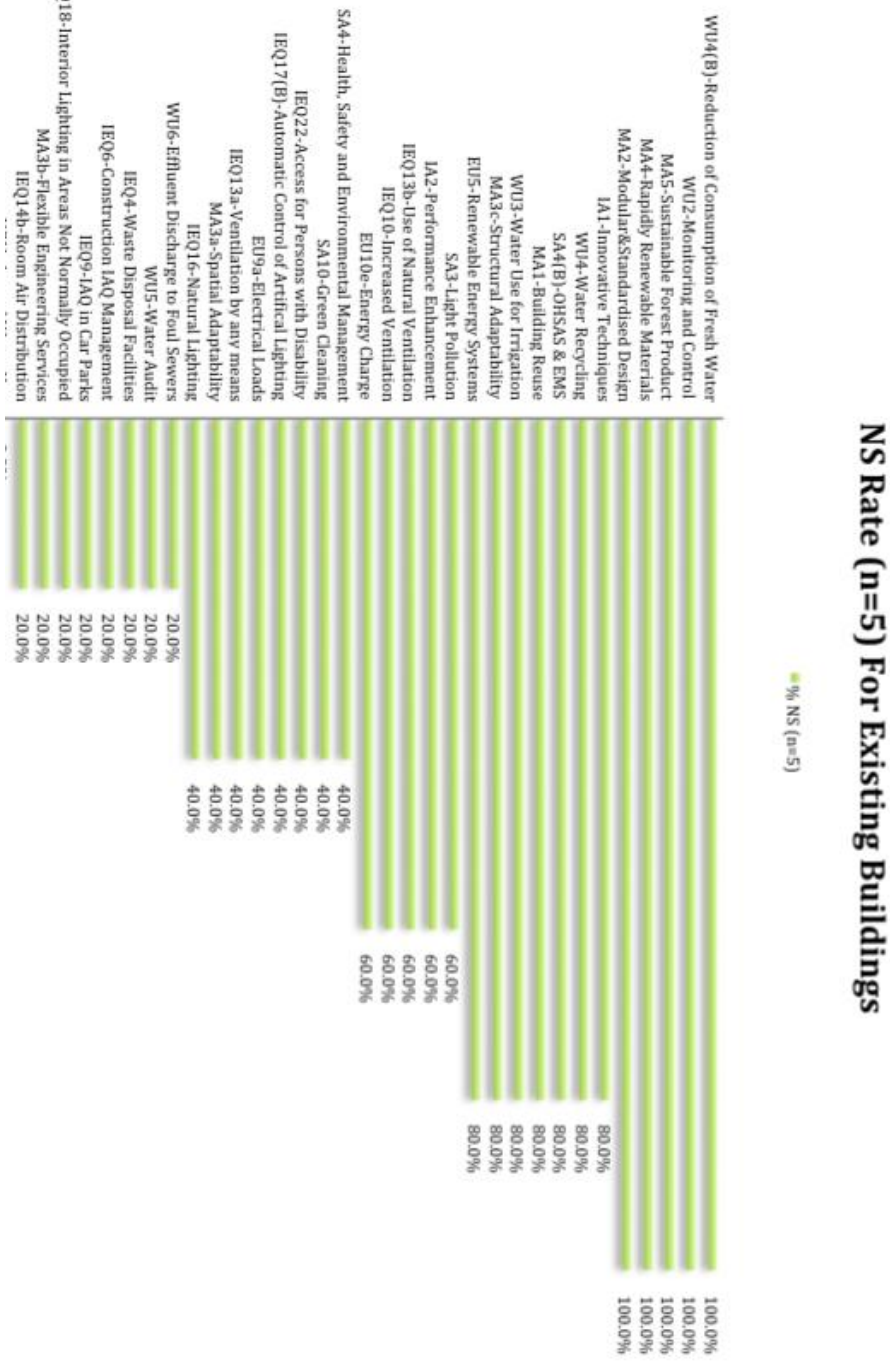



IEQ21 - Vibration 21.2% 42.4%
MA9 - Regional Manufatured Materials 6.1% 40.5%
IEQ13b - Room Air Distribution 27.3% 40.5%
IEQ23a - Amenities for the benefit of building users 9.1% 39.5%
SA8b - Elevated Temperatures 9.1% 39.0%
SA2a - Car Parking Provisions 3.0% 37.1%
MA10 - Demolition Waste Reduction 15.2% 36.7%
SA14 - Noise from Building Equipment 0.0% 35.2%
IEQ17 - Interior Lighting in Areas Not Normally Occupied 6.1% 34.3%
EU8 - Clothes Drying Facilities 9.1% 32.9%
SA3a - Provison of Basic Services 3.0% 32.4%
IEQ9 - Increased Ventilation 15.2% 31.0%
IEQ16 - Interior Lighting in Normally Occupied Areas 6.1% 31.0%
IEQ22 - Access for Persons with Disability 6.1% 30.0%
EU9 - Energy Efficient Appliances 9.1% 29.0%
WU5 - Water Efficient Appliances 6.1% 28.6%
SA3b - Neighbourhood Recreational Facilities 0.0% 28.1%
IEQ1 - Security 0.0% 28.1%
WU6 - Effluent Discharge to Foul Sewers 3.0% 26.7%
SA2b - Public Transport 0.0% 26.7%
SA4 - Site Design Appraisal 0.0% 26.2%
MA8b - Ozone Depleting Materials 3.0% 26.2%
IEQ8 - IAQ in Car Parks 6.1% 26.2%
IEQ13a - Temperature 3.0% 26.2%
EU2 - Peak Electricity Demand Reduction 9.1% 26.2%
EU12 - Metering and Monitoring 9.1% 26.2%
WU1 - Annual Water Use 0.0% 25.2%
EU11c - Operator Training and Operation and Maintenance Facilities 0.0% 25.2%
MA8a - Refrigerants 0.0% 24.8%
SA12 - Noise during Construction 3.0% 24.3%
IEQ2 - Plumbing and Drainage 0.0% 24.3%
IEQ11a - Source Control 3.0% 24.3%
IEQ5b - Filter Replacement and Flush-out 6.1% 23.8%
SA11 - Air Pollution during Construction 0.0% 23.3%
IEQ7 - Indoor Sources of Air Pollution 6.1% 23.3%
IEQ3 - Biological Contamination 3.0% 23.3%
IEQ4 - Waste Disposal Facilities 0.0% 22.9%
IEQ6 - Outdoor Sources of Air Pollution 3.0% 22.4%
IEQ14b - Performance with Air-conditioning 3.0% 22.4%
SA6 - Culture Heritage 0.0% 21.9%
SA13 - Water Pollution during Construction 0.0% 21.9%
SA10 - Environmental Management Plan 0.0% 21.9%
EU5 - Lighting Systems in Mechanically Ventilated Buildings 3.0% 20.5%
EU4 - Ventilation Systems in Mechanically Ventilated Spaces 0.0% 20.5%
EU1 - Reduction of CO2 Emission 9.1% 20.5%
IEQ5a - Construction IAQ Management 3.0% 20.0%
EU11b - Energy Management Manual 6.1% 20.0%
EU10b - Commissioning Plan 0.0% 20.0%
EU10d - Commissioning Reports 0.0% 19.0%
EU10c - Commissioning 0.0% 19.0%
EU10a - Commissioning Specifications 0.0% 19.0%
EU11a - Operations and Maintenance Manual 0.0% 18.6%
IA3 - BEAM Professional 0.0% 12.4%

Appendix I: Contested Rate for Existing Buildings

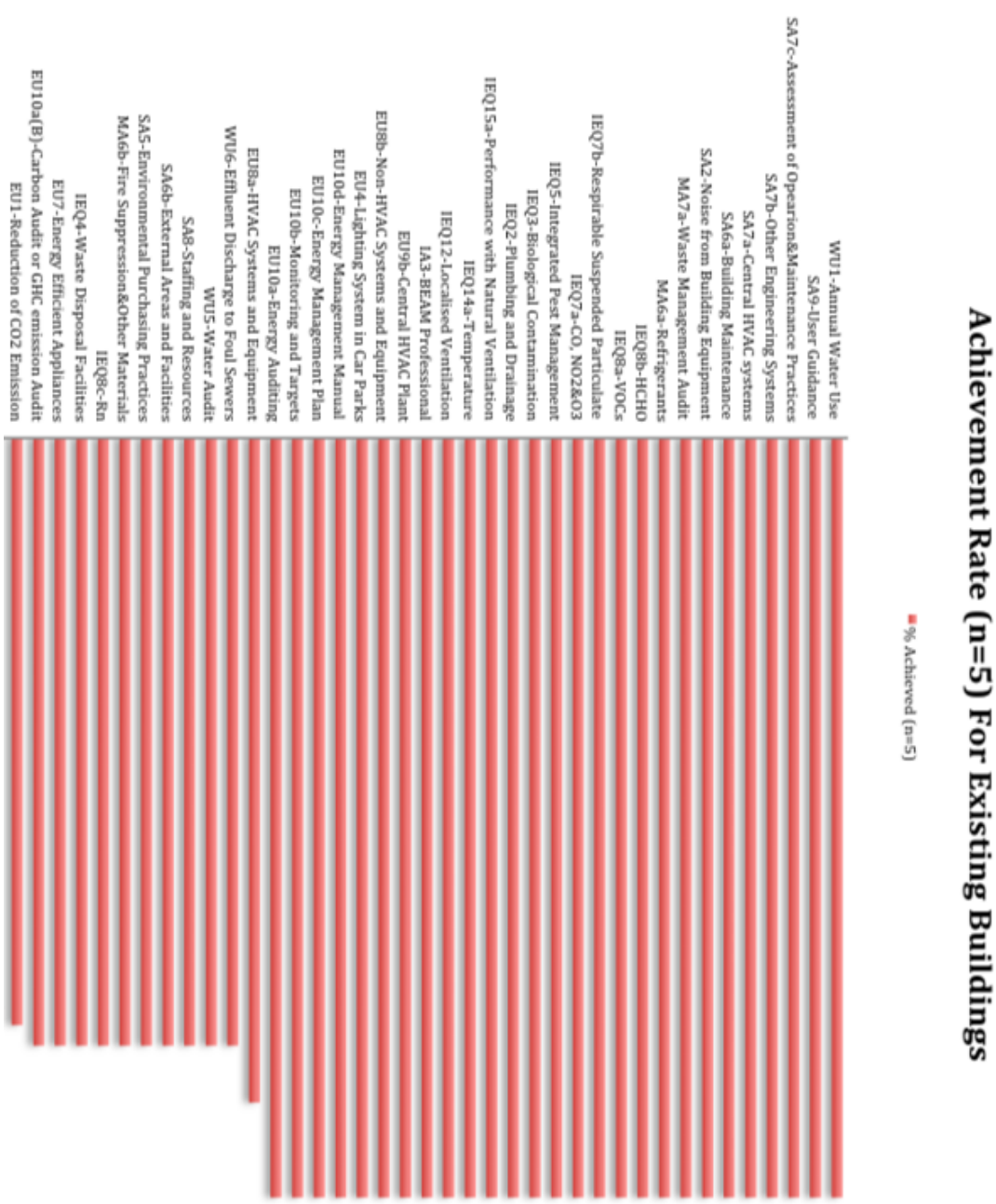


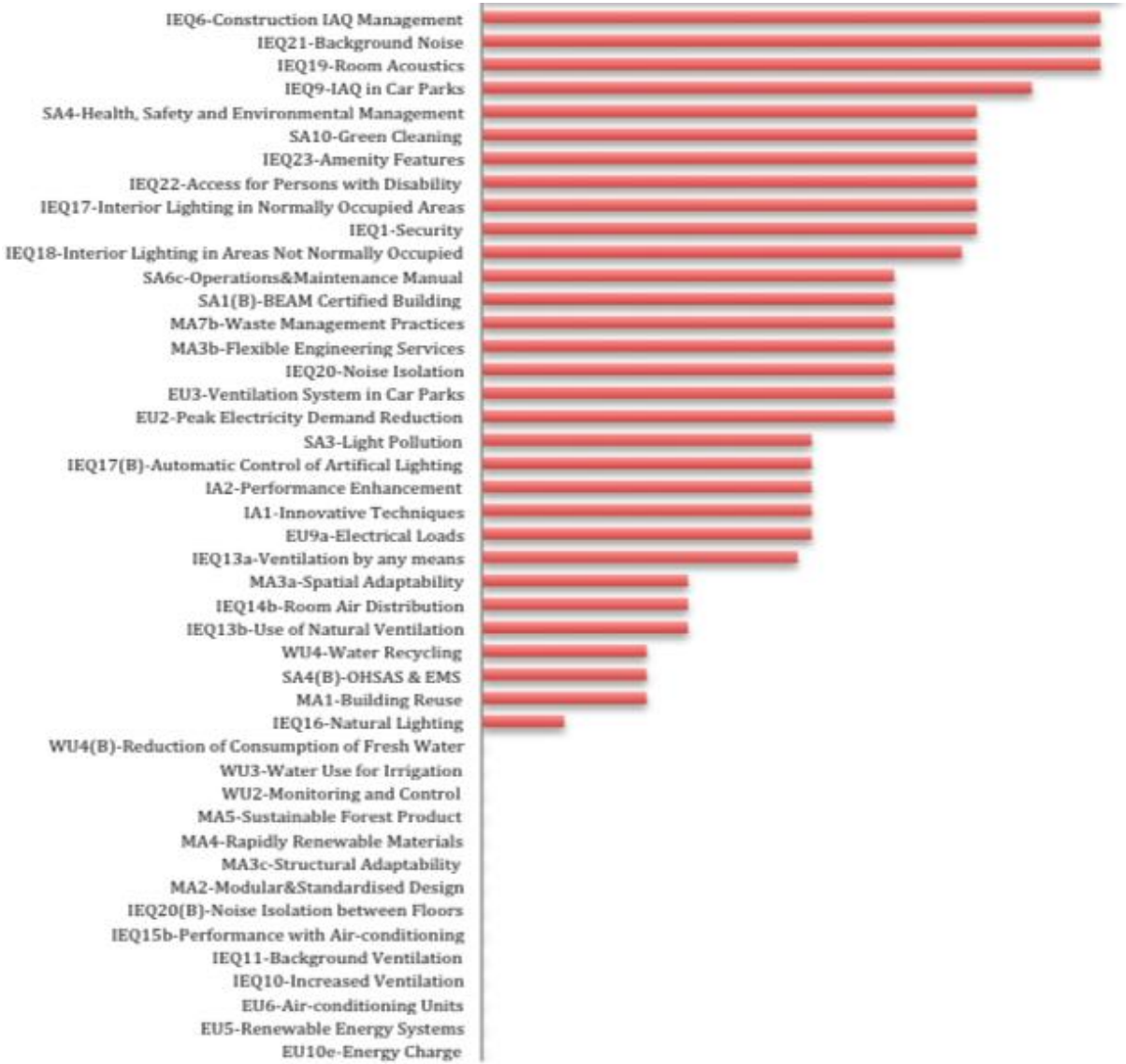
Appendix J: Not Submitted Rate for Existing Buildings



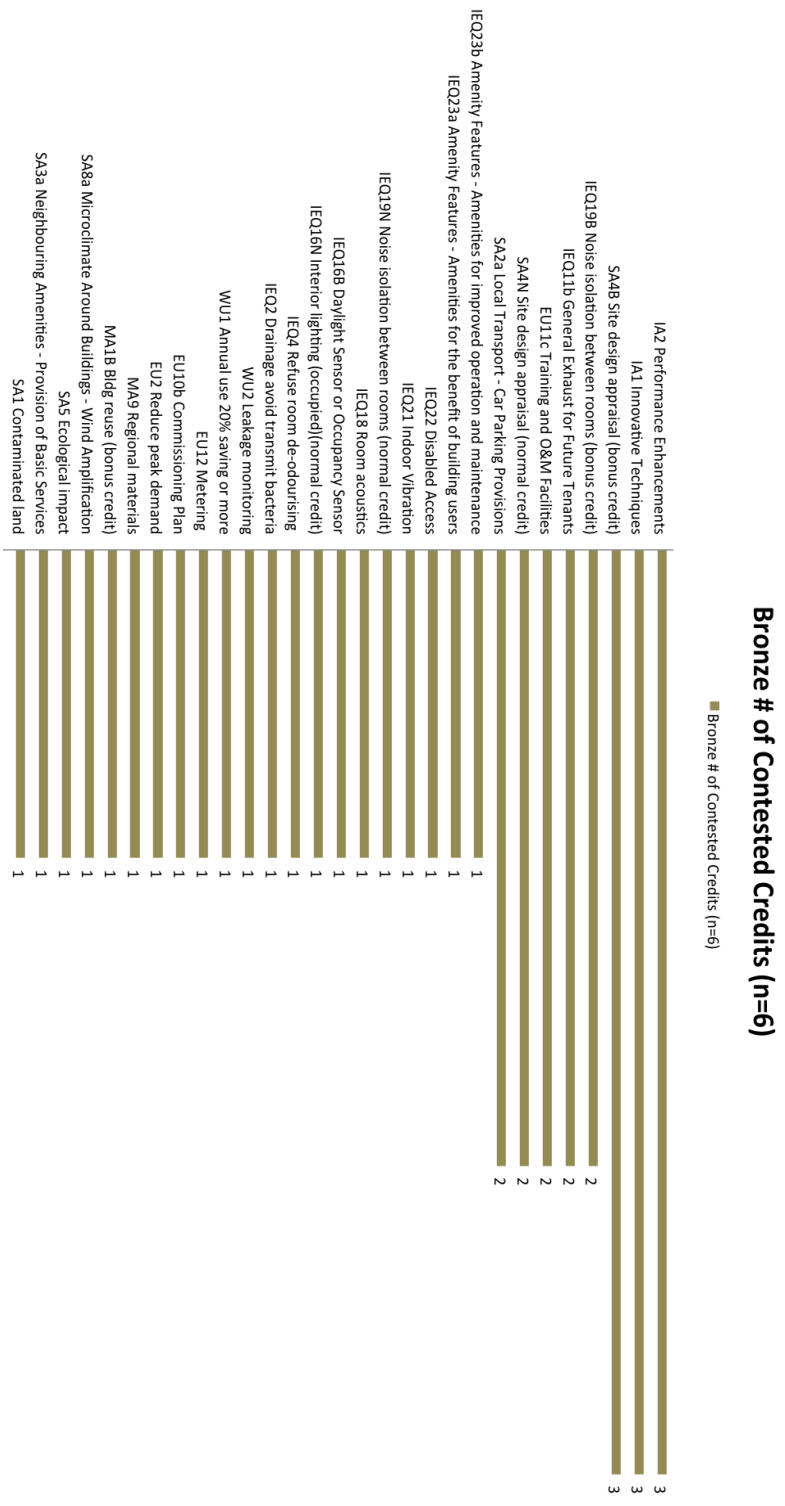
WU1-Annual Water Use	0.0%
SA9-User Guidance	0.0%
SA7c-Assessment of Opearion&Maintenance Practices	0.0%
SA7b-Other Engineering Systems	0.0%
SA7a-Central HVAC systems	0.0%
SA6a-Building Maintenance	0.0%
SA2-Noise from Building Equipment	0.0%
MA7a-Waste Management Audit	0.0%
MA6a-Refrigerants	0.0%
IEQ8b-HCHO	0.0%
IEQ8a-VOCs	0.0%
IEQ7b-Respirable Suspended Particulate	0.0%
IEQ7a-CO, NO2&O3	0.0%
IEQ5-Integrated Pest Management	0.0%
IEQ3-Biological Contamination	0.0%
IEQ2-Plumbing and Drainage	0.0%
IEQ15a-Performance with Natural Ventilation	0.0%
IEQ14a-Temperature	0.0%
IEQ12-Localised Ventilation	0.0%
IA3-BEAM Professional	0.0%
EU9b-Central HVAC Plant	0.0%
EU8b-Non-HVAC Systems and Equipment	0.0%
EU4-Lighting System in Car Parks	0.0%
EU10d-Energy Management Manual	0.0%
EU10c-Energy Management Plan	0.0%
EU10b-Monitoring and Targets	0.0%
EU10a-Energy Auditing	0.0%
EU8a-HVAC Systems and Equipment	0.0%
SA8-Staffing and Resources	0.0%
SA6b-External Areas and Facilities	0.0%
SA5-Environmental Purchasing Practices	0.0%
MA6b-Fire Suppression&Other Materials	0.0%
IEQ8c-Rn	0.0%
EU7-Energy Efficient Appliances	0.0%
EU10a(B)-Carbon Audit or GHC emission Audit	0.0%
EU1-Reduction of CO2 Emission	0.0%
IEQ21-Background Noise	0.0%
IEQ19-Room Acoustics	0.0%
IEQ23-Amenity Features	0.0%
IEQ17-Interior Lighting in Normally Occupied Areas	0.0%
IEQ1-Security	0.0%
SA6c-Operations&Maintenance Manual	0.0%
SA1(B)-BEAM Certified Building	0.0%
MA7b-Waste Management Practices	0.0%
IEQ20-Noise Isolation	0.0%
EU3-Ventilation System in Car Parks	0.0%
EU2-Peak Electricity Demand Reduction	0.0%
IEQ20(B)-Noise Isolation between Floors	0.0%
IEQ15b-Performance with Air-conditioning	0.0%
IEQ11-Background Ventilation	0.0%
EU6-Air-conditioning Units	0.0%

Appendix K: Achievement Rate for Existing Buildings

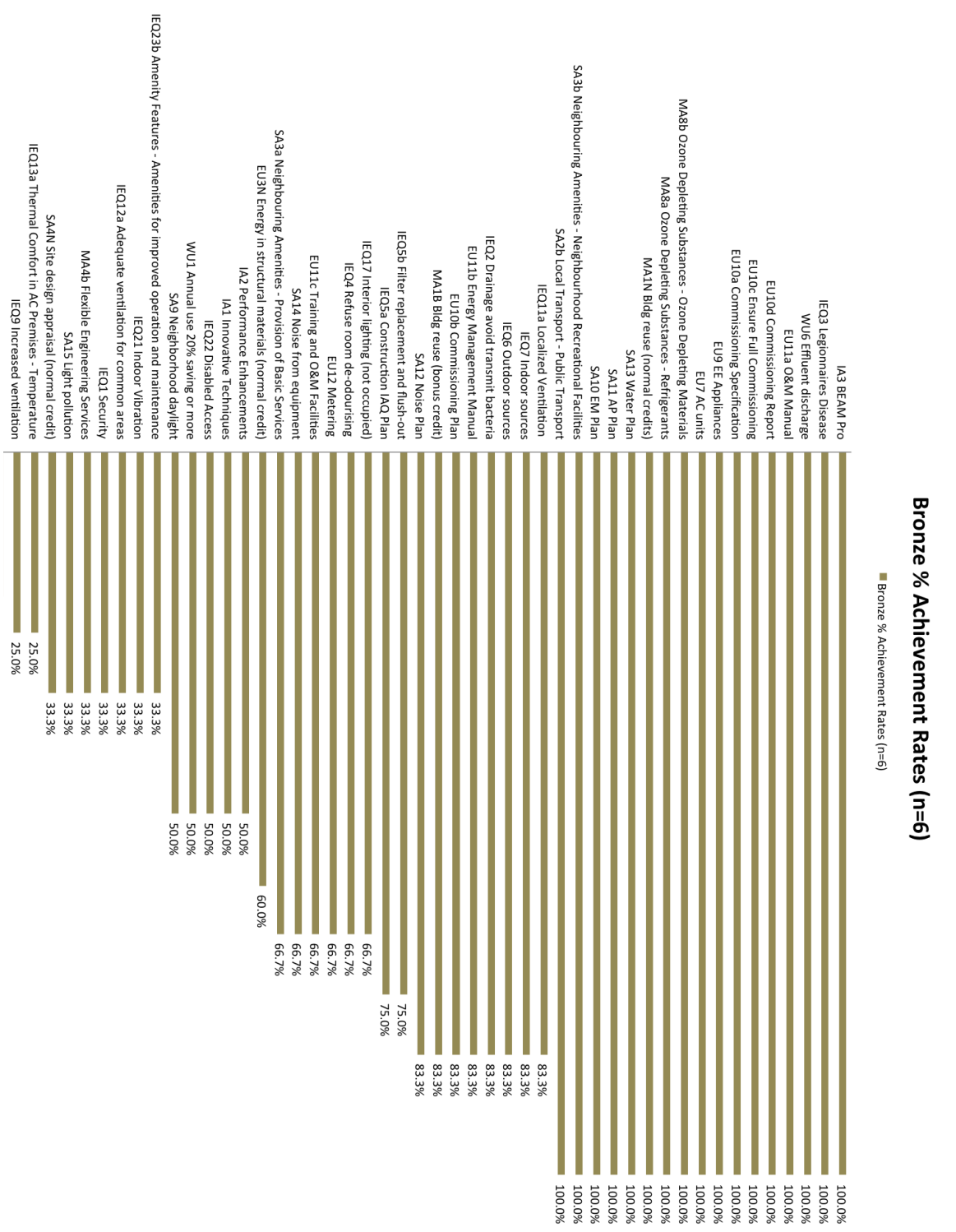


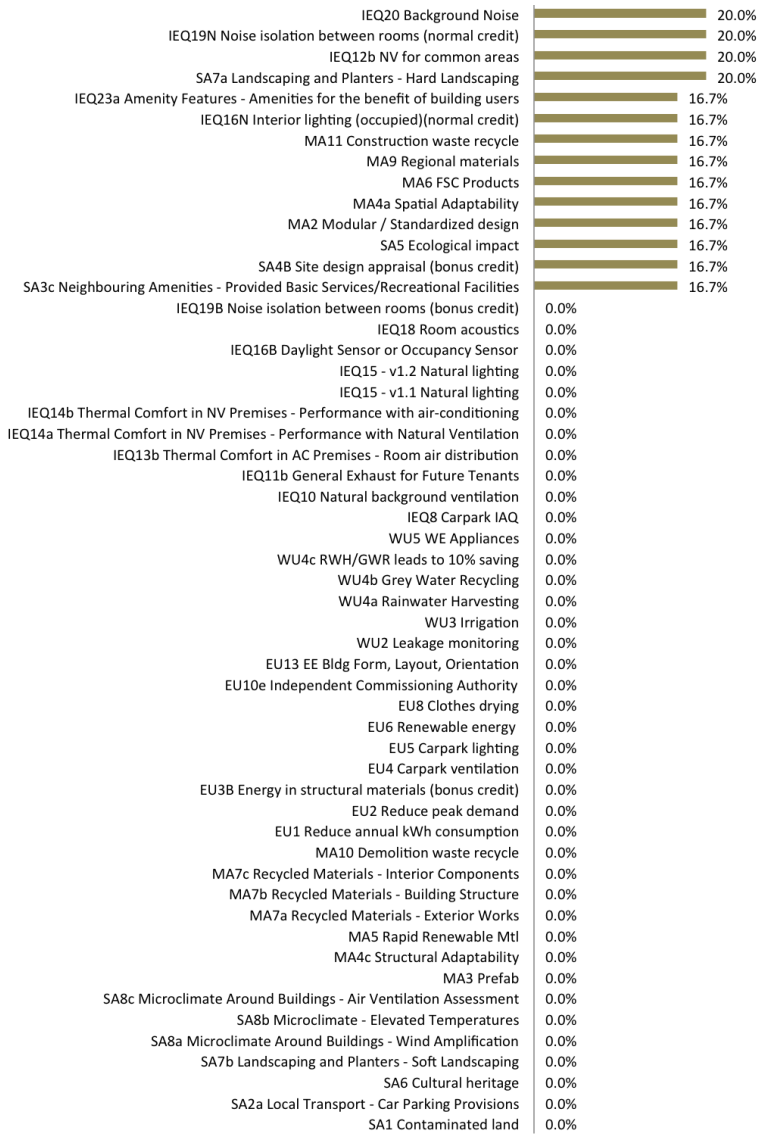

IEQ6-Construction IAQ Management
IEQ21-Background Noise
IEQ19-Room Acoustics
IEQ9-IAQ in Car Parks
SA4-Health, Safety and Environmental Management
SA10-Green Cleaning
IEQ23-Amenity Features
IEQ22-Access for Persons with Disability
IEQ17-Interior Lighting in Normally Occupied Areas
IEQ1-Security
IEQ18-Interior Lighting in Areas Not Normally Occupied
SA6c-Operations&Maintenance Manual
SA1(B)-BEAM Certified Building
MA7b-Waste Management Practices
MA3b-Flexible Engineering Services
IEQ20-Noise Isolation
EU3-Ventilation System in Car Parks
EU2-Peak Electricity Demand Reduction
SA3-Light Pollution
IEQ17(B)-Automatic Control of Artifical Lighting
IA2-Performance Enhancement
IA1-Innovative Techniques
EU9a-Electrical Loads
IEQ13a-Ventilation by any means
MA3a-Spatial Adaptability
IEQ14b-Room Air Distribution
IEQ13b-Use of Natural Ventilation
WU4-Water Recycling
SA4(B)-OHSAS & EMS
MA1-Building Reuse
IEQ16-Natural Lighting
WU4(B)-Reduction of Consumption of Fresh Water
WU3-Water Use for Irrigation
WU2-Monitoring and Control
MA5-Sustainable Forest Product
MA4-Rapidly Renewable Materials
MA3c-Structural Adaptability
MA2-Modular&Standardised Design
IEQ20(B)-Noise Isolation between Floors
IEQ15b-Performance with Air-conditioning
IEQ11-Background Ventilation
IEQ10-Increased Ventilation
EU6-Air-conditioning Units
EU5-Renewable Energy Systems
EU10e-Energy Charge

Appendix L: Contested Credits for Conversion Projects

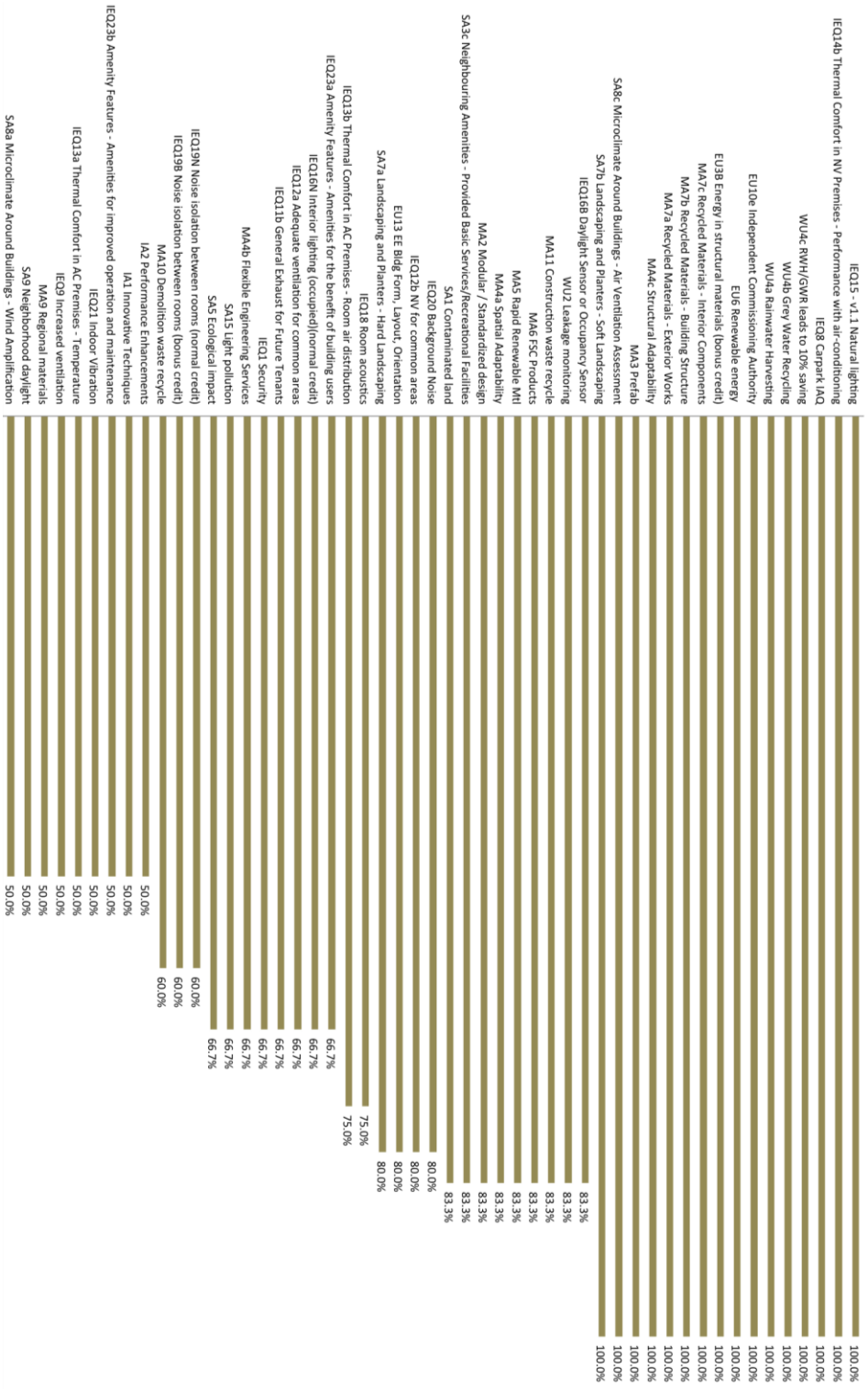


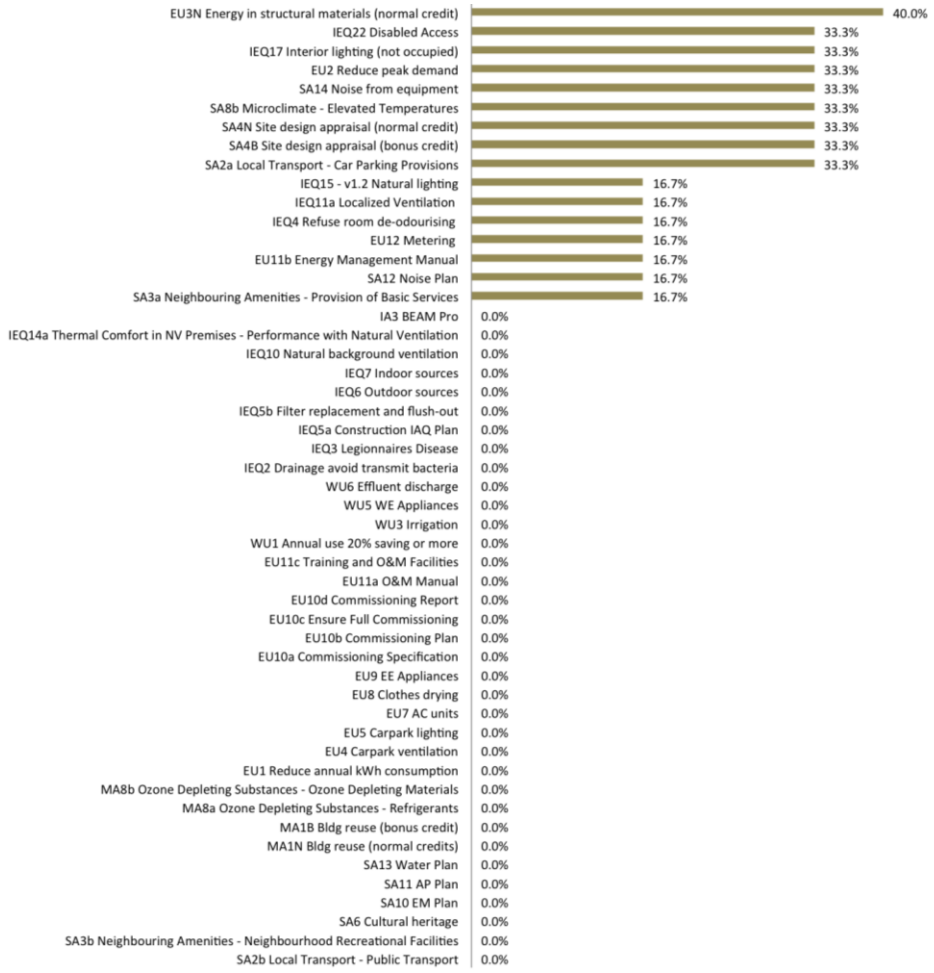
Appendix M: Achievement % for Conversion Projects




IEQ20 Background Noise 20.0%
IEQ19N Noise isolation between rooms (normal credit) 20.0%
IEQ12b NV for common areas 20.0%
SA7a Landscaping and Planters - Hard Landscaping 20.0%
IEQ23a Amenity Features - Amenities for the benefit of building users 16.7%
IEQ16N Interior lighting (occupied)(normal credit) 16.7%
MA11 Construction waste recycle 16.7%
MA9 Regional materials 16.7%
MA6 FSC Products 16.7%
MA4a Spatial Adaptability 16.7%
MA2 Modular / Standardized design 16.7%
SA5 Ecological impact 16.7%
SA4B Site design appraisal (bonus credit) 16.7%
SA3c Neighbouring Amenities - Provided Basic Services/Recreational Facilities 16.7%
IEQ19B Noise isolation between rooms (bonus credit) 0.0%
IEQ18 Room acoustics 0.0%
IEQ16B Daylight Sensor or Occupancy Sensor 0.0%
IEQ15 - v1.2 Natural lighting 0.0%
IEQ15 - v1.1 Natural lighting 0.0%
IEQ14b Thermal Comfort in NV Premises - Performance with air-conditioning 0.0%
IEQ14a Thermal Comfort in NV Premises - Performance with Natural Ventilation 0.0%
IEQ13b Thermal Comfort in AC Premises - Room air distribution 0.0%
IEQ11b General Exhaust for Future Tenants 0.0%
IEQ10 Natural background ventilation 0.0%
IEQ8 Carpark IAQ 0.0%
WU5 WE Appliances 0.0%
WU4c RWH/GWR leads to 10% saving 0.0%
WU4b Grey Water Recycling 0.0%
WU4a Rainwater Harvesting 0.0%
WU3 Irrigation 0.0%
WU2 Leakage monitoring 0.0%
EU13 EE Bldg Form, Layout, Orientation 0.0%
EU10e Independent Commissioning Authority 0.0%
EU8 Clothes drying 0.0%
EU6 Renewable energy 0.0%
EU5 Carpark lighting 0.0%
EU4 Carpark ventilation 0.0%
EU3B Energy in structural materials (bonus credit) 0.0%
EU2 Reduce peak demand 0.0%
EU1 Reduce annual kWh consumption 0.0%
MA10 Demolition waste recycle 0.0%
MA7c Recycled Materials - Interior Components 0.0%
MA7b Recycled Materials - Building Structure 0.0%
MA7a Recycled Materials - Exterior Works 0.0%
MA5 Rapid Renewable Mtl 0.0%
MA4c Structural Adaptability 0.0%
MA3 Prefab 0.0%
SA8c Microclimate Around Buildings - Air Ventilation Assessment 0.0%
SA8b Microclimate - Elevated Temperatures 0.0%
SA8a Microclimate Around Buildings - Wind Amplification 0.0%
SA7b Landscaping and Planters - Soft Landscaping 0.0%
SA6 Cultural heritage 0.0%
SA2a Local Transport - Car Parking Provisions 0.0%
SA1 Contaminated land 0.0%

Appendix N: Not Submitted % for Conversion Projects




EU3N Energy in structural materials (normal credit) 40.0%
IEQ22 Disabled Access 33.3%
IEQ17 Interior lighting (not occupied) 33.3%
EU2 Reduce peak demand 33.3%
SA14 Noise from equipment 33.3%
SA8b Microclimate - Elevated Temperatures 33.3%
SA4N Site design appraisal (normal credit) 33.3%
SA4B Site design appraisal (bonus credit) 33.3%
SA2a Local Transport - Car Parking Provisions 33.3%
IEQ15 - v1.2 Natural lighting 16.7%
IEQ11a Localized Ventilation 16.7%
IEQ4 Refuse room de-odourising 16.7%
EU12 Metering 16.7%
EU11b Energy Management Manual 16.7%
SA12 Noise Plan 16.7%
SA3a Neighbouring Amenities - Provision of Basic Services 16.7%
IA3 BEAM Pro 0.0%
IEQ14a Thermal Comfort in NV Premises - Performance with Natural Ventilation 0.0%
IEQ10 Natural background ventilation 0.0%
IEQ7 Indoor sources 0.0%
IEQ6 Outdoor sources 0.0%
IEQ5b Filter replacement and flush-out 0.0%
IEQ5a Construction IAQ Plan 0.0%
IEQ3 Legionnaires Disease 0.0%
IEQ2 Drainage avoid transmit bacteria 0.0%
WU6 Effluent discharge 0.0%
WU5 WE Appliances 0.0%
WU3 Irrigation 0.0%
WU1 Annual use 20% saving or more 0.0%
EU11c Training and O&M Facilities 0.0%
EU11a O&M Manual 0.0%
EU10d Commissioning Report 0.0%
EU10c Ensure Full Commissioning 0.0%
EU10b Commissioning Plan 0.0%
EU10a Commissioning Specification 0.0%
EU9 EE Appliances 0.0%
EU8 Clothes drying 0.0%
EU7 AC units 0.0%
EU5 Carpark lighting 0.0%
EU4 Carpark ventilation 0.0%
EU1 Reduce annual kWh consumption 0.0%
MA8b Ozone Depleting Substances - Ozone Depleting Materials 0.0%
MA8a Ozone Depleting Substances - Refrigerants 0.0%
MA1B Bldg reuse (bonus credit) 0.0%
MA1N Bldg reuse (normal credits) 0.0%
SA13 Water Plan 0.0%
SA11 AP Plan 0.0%
SA10 EM Plan 0.0%
SA6 Cultural heritage 0.0%
SA3b Neighbouring Amenities - Neighbourhood Recreational Facilities 0.0%
SA2b Local Transport - Public Transport 0.0%

Appendix O: Unfair Conversion Project Credits

1. SA1 BONUS Contaminated Land: A site contamination assessment can not be done since the buildings are already built.
2. SA4 Site design appraisal: A site design appraisal is difficult because many of the building characteristics, e.g. development height profile, view corridor, size of development, vehicular circulation, etc. could not be changed.
3. SA8a Wind Amplification: This should be NA for all industrial building revitalization projects according to the BEAM Circular Letter 2012.110.
4. SA8c Air Ventilation Assessment: This should be NA for all industrial building revitalization projects according to the BEAM Circular Letter 2012.110.
5. SA9 Neighborhood Daylight Access: This should be NA for all industrial building revitalization projects according to the BEAM Circular Letter 2012.110.
6. MA2 Modular and Standardized Design: This should be NA for all conversion projects as the structural elements already exist in the building.
7. MA3 Prefabrication: This should be NA for all conversion projects as the structural elements already exist in the building.
8. MA4c Structural Adaptability: This should be NA for all industrial building revitalization projects according to the BEAM Circular Letter 2012.110.
9. MA6 Sustainable Forest Products: This should be NA for buildings that are keeping the wood that is part of the original design of the building.
10. MA7 Recycled Materials: This credit should be NA depending on the nature of the conversion project. For projects not changing the outside surface or structure of the building MA7a and MA7b should be exempt. MA7c should still apply to all conversion projects.
11. EU13 Energy Efficient Building Layout: This credit should be modified to better apply to conversion projects. For this credit at least 3 of the 5 sub-categories must be met. One of these categories is building orientation, which can not be changed during the conversion. Maybe for conversion projects only 2 of the categories should have to be met.

Appendix P: Building Manager Interview Protocol for Building C

Introduction:
We are students from Worcester Polytechnic Institute located in Massachusetts working on a project supported by the Hong Kong Green Building Council. Our goal is to make suggestions to modify the green building rating tool, BEAM Plus. To do so, we need to better understand how BEAM Plus certified buildings perform and are maintained after certification. We are hoping to ask you some questions about this building in order to supplement our research. Your responses will remain anonymous and will not be identifiable without your permission.
Questions:

1. Who made the decision to have this building become BEAM Plus certified? Why did they choose to get the building certified?
2. Is maintenance of this building difficult because of any of the green technologies located throughout the building? If so why?
3. Have you ever "turned off" any of the green technologies in the building? If so why?
4. Is there any signage posted on the building about its BEAM Plus certification? If so, may we see it?
5. Has any information been provided to the occupants of the building about the BEAM Plus certification, about how to properly use the green technologies, or about the benefits of the green technologies? If yes, please explain.

Conclusion:
Thank you for allowing our team to interview you. We appreciate you taking time out of your day for us. We will send you a transcript from this interview for your approval before using any of the information in our report. Your responses will remain anonymous unless you give us permission to use your name. Thank you again.

Appendix Q: Building Manager Interview Protocol for Building D

Introduction:
We are students from Worcester Polytechnic Institute located in Massachusetts working on a project for the Hong Kong Green Building Council. Our goal is to make suggestions to modify the green building rating tool, BEAM Plus. To do so, we need to better understand how BEAM Plus certified buildings perform and are maintained after certification. We are hoping to ask you some questions about this building in order to supplement our research. Your responses will remain anonymous and will not be identifiable with this building.
Questions:

1. Are you aware that this building is BEAM Plus certified?
2. Have you ever "turned off" or "not used" any of the green technologies in the building? If so, which ones and why?
3. Have you ever noticed occupants of the building turning off green technologies or mis-using them? Please explain.
4. Has any signage been posted on the building about its BEAM Plus certification? If so, where and may we see it?
5. In this long-history estate, is the population aging? What is the current profile?
6. How does the population profile affects the building's operations? For example, hygiene and pest management. Occupant willingness to sort the waste, and recycle waste – may need money incentives, exchange waste for money.
7. Is it difficult to educate the older occupants? For example how to use the facilities inside the rented apartment, proper maintenance, fault reporting, etc.
8. How does the population profile affects the design of renovation works? For example, may need to retrofit facilities for the aged – e.g. fitness exercise equipment for the aged persons. More ramps and wheelchair-friendly facilities.
9. We know that community engagement exercise is conducted to obtain residents' opinions on the renovation works and public space design. Do you encounter difficulties in the exercise? For example, very high expectations from residents; or contradicting opinions.
10. How often do you refer to the manual for these buildings regarding the green technologies?

11. Do you have any other difficulties with maintenance of this building because of any of the green technologies? If so, why?

Conclusion:
Thank you for allowing our team to interview you. We appreciate you taking time out of your day for us. We will send you a transcript from this interview for your approval before using any of the information in our report. Your responses will remain anonymous and the building will not be identifiable without your permission. Thank you again.

Appendix R: Building Manager Interview Protocol for Building E

Introduction:
We are students from Worcester Polytechnic Institute located in Massachusetts working on a project for the Hong Kong Green Building Council. Our goal is to make suggestions to modify the green building rating tool, BEAM Plus. To do so, we need to better understand how BEAM Plus certified buildings perform and are maintained after certification. We are hoping to ask you some questions about this building in order to supplement our research. Your responses will remain anonymous and will not be identifiable with this building.
Questions:

1. Are you aware that this building is BEAM Plus certified?
2. Have you ever "turned off" or "not used" any of the green technologies in the building? If so, which ones and why?
3. Have you ever noticed occupants of the building turning off green technologies or mis-using them? Please explain.
4. Has any signage been posted on the building about its BEAM Plus certification? If so, where and may we see it?
5. Are the LED lighting panels reliable? Repeated failures of the lamps have occurred in the male toilet on 1/F.
6. Is the oil-free chiller reliable? (It is a new technology.)
7. The waterfall between the two outdoor staircases was converted to a dry planter. What was the reason?
8. How much rain water has been stored recently? How is the water used to irrigate? By manual means? (exp answer yes) Why not use an automatic drip line system to control the time of irrigation precisely?
9. How does user behaviour affect energy consumption? What is being done to affect user behaviour?
10. How often do you refer to the manual for these buildings regarding the green technologies?
11. Do you have any other difficulties with maintenance of this building because of any of the green technologies? If so, why?

Conclusion:
Thank you for allowing our team to interview you. We appreciate you taking time out of your day for us. We will send you a transcript from this interview for your approval before using any of the information in our report. Your responses will remain anonymous and the building will not be identifiable without your permission. Thank you again.

Appendix S: Questionnaire for Occupants

綠色建築問卷調查

Green Building Questionnaire

1. 你是否認為這棟建築是一棟評定的綠色建築？(Are you aware that this building is a certified green building?)
   是(YES)　　否(NO)　　不確定(Not Sure)
   如果是，你認為評定機制的名稱是 (If yes, please provide the name of the certification scheme)_____

2. 你是否認為這棟建築有綠色建築的特徵？(Do you think this building has green features?)
   是(YES)　　否(NO)　　不確定(Not Sure)
   如果是，請列舉至少一個你認為的綠色特徵 (Please elaborate) :

3. 你是否認為這棟建築是節能的？(Do you think this building is energy-efficient?)
   是(YES)　　否(NO)　　不確定(Not Sure)
   請列舉你認為節能／不節能的方面 (Please elaborate)：

4. 你是否覺得教室內的環境舒適,比如室內温度，空气质量，灯光？(Are you satisfied with the indoor environment in the classroom, for example: temperature, air quality, lighting?)
   是(YES)　　否(NO)　　不確定(Not Sure)
   請列舉你認為舒适／不舒适的方面 (Please elaborate)：

Appendix T: Observation Report for Building A

Observations:

- **Task Lighting:**
  The lobby of the ground floor has task lighting with brighter lights near the information boards at the edges of the room.

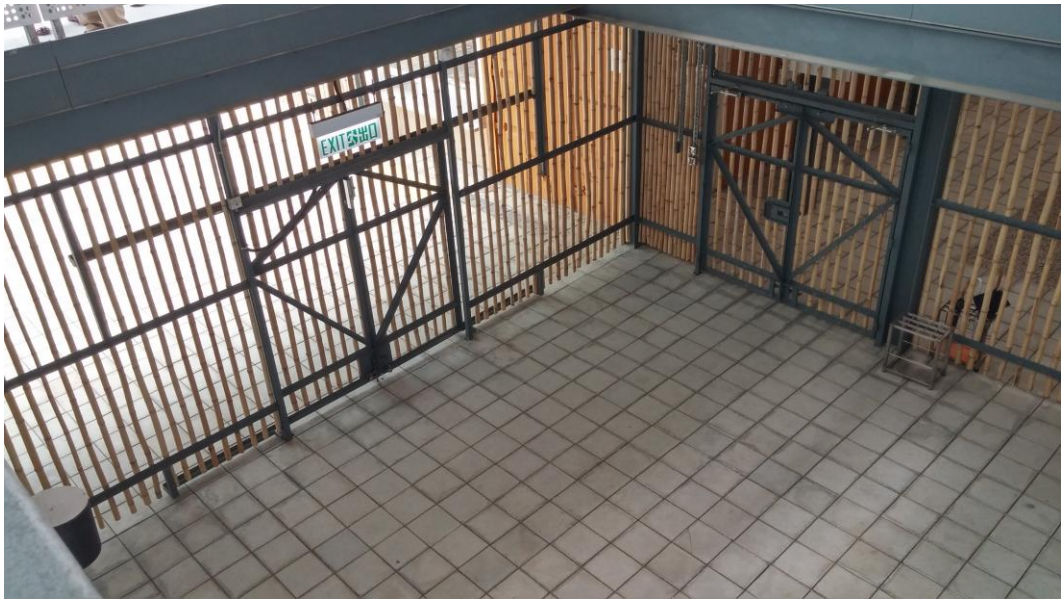
- **Daylighting:**
  The shades were all shut on 3 of the 4 sides of the building. The shades were open on the east side of the building. We couldn't tell if there were shades on the east side or not.

- **Natural Ventilation:**
  None of the windows were open anywhere. The building was very close to a busy road and under a highway, so opening the windows would be very noisy. They use the air conditioning in the winter instead of opening a window.

- **Thermal Comfort:**
  Very comfortable temperature inside.
- **Rain water harvesting system:**
  It exists, but we couldn't see much of it.

- **Spatial Adaptability:**
  The ground floor lobby was a big open space that could be adapted for a variety of uses.

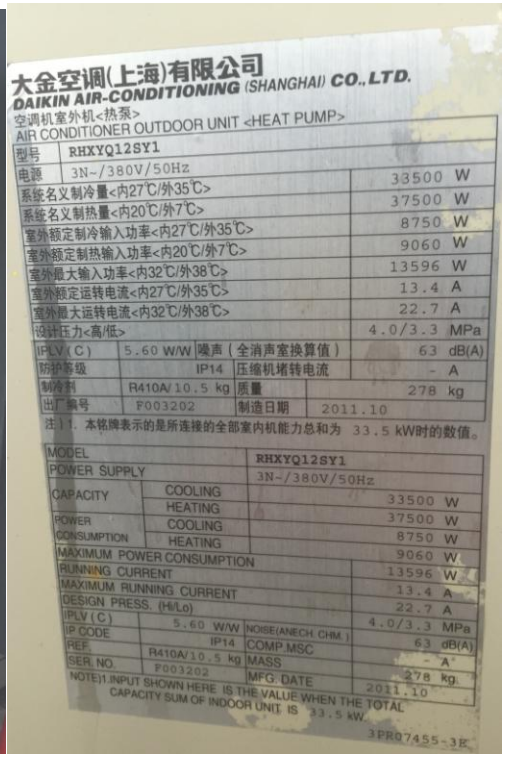
- **Increased Ventilation:**
  The ventilation was always on in all of the rooms that we went in.
- **Bamboo:**
  All of the exits have bamboo. Not sure if bamboo is a fire hazard.



- **Durability of Container:**
  They have had no water leakage issues from typhoons. The building is protected because it is under the highway.

- **Cross Ventilation:**
  Bamboo allows air flow through the building's courtyard.

- **Heating:**
  Heat pump.



大金空调(上海)有限公司
DAIKIN AIR-CONDITIONING (SHANGHAI) CO.,LTD.
空调机室外机<热泵>
AIR CONDITIONER OUTDOOR UNIT <HEAT PUMP>

型号	RHXYQ12SY1		
电源	3N~/380V/50Hz		
系统名义制冷量<内27℃/外35℃>			33500 W
系统名义制热量<内20℃/外7℃>			37500 W
室外额定制冷输入功率<内27℃/外35℃>			8750 W
室外额定制热输入功率<内20℃/外7℃>			9060 W
室外最大输入功率<内32℃/外38℃>			13596 W
室外额定运转电流<内27℃/外35℃>			13.4 A
室外最大运转电流<内32℃/外38℃>			22.7 A
设计压力<高/低>			4.0/3.3 MPa
IPLV(C)	5.60 W/W	噪声(全消声室换算值)	63 dB(A)
防护等级	IP14	压缩机堵转电流	- A
制冷剂	R410A/10.5 kg	质量	278 kg
出厂编号	F003202	制造日期	2011.10

注)1. 本铭牌表示的是所连接的全部室内机能力总和为 33.5 kW时的数值。

MODEL		RHXYQ12SY1
POWER SUPPLY		3N~/380V/50Hz
CAPACITY	COOLING	33500 W
	HEATING	37500 W
POWER CONSUMPTION	COOLING	8750 W
	HEATING	9060 W
MAXIMUM POWER CONSUMPTION		13596 W
RUNNING CURRENT		13.4 A
MAXIMUM RUNNING CURRENT		22.7 A
DESIGN PRESS. (Hi/Lo)		4.0/3.3 MPa
IPLV(C)	5.60 W/W	NOISE(ANECH. CHM.) 63 dB(A)
IP CODE	IP14	COMP.MSC - A
REF.	R410A/10.5 kg	MASS 278 kg
SER. NO.	F003202	MFG. DATE 2011.10

NOTE)1.INPUT SHOWN HERE IS THE VALUE WHEN THE TOTAL CAPACITY SUM OF INDOOR UNIT IS 33.5 kW.

3PR07455-3E

- **Water efficient devices:**
  Double flush toilets in bathrooms.

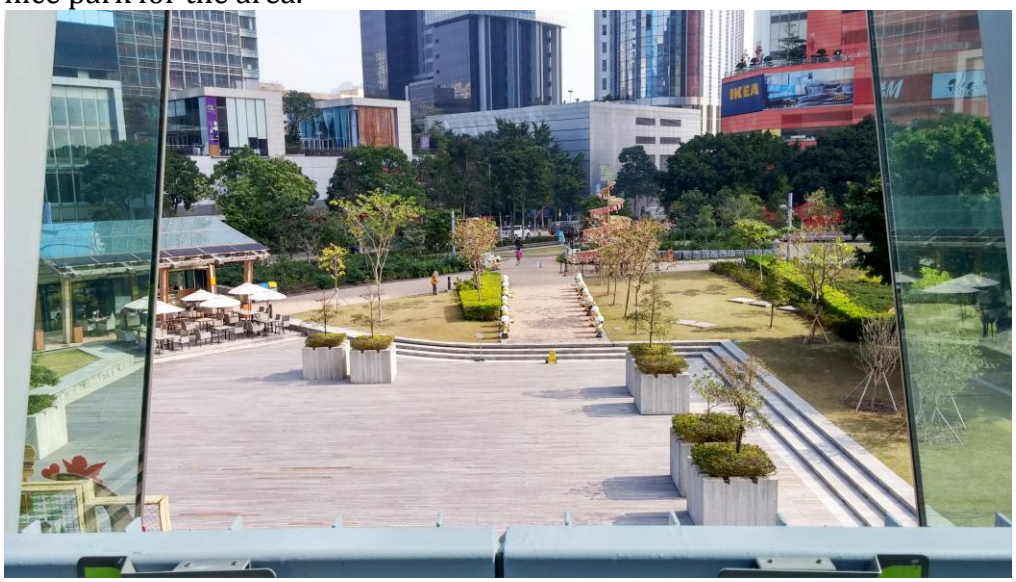
- **Education:**
  4 Posters highlighting green technologies throughout the building.

- **Disability:**
  Wheelchair ramp.

- **Security:**
  Security guard.
- **Light Sensors:**
  There were no light sensors in the bathroom.

Appendix U: Observation Report for Building B

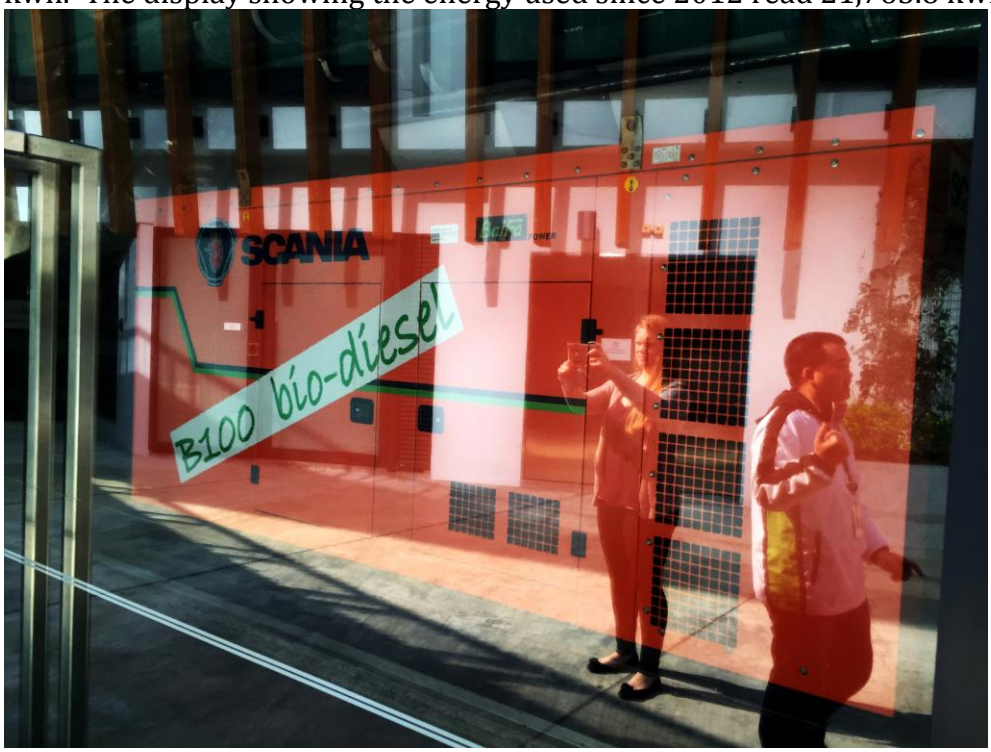
Outdoor Seating Area: Lots of public use of the outdoor seating area. It provides a nice park for the area.



Large soft scaping area (woodland): The trees were more barren (probably because it is winter). Maintenance were watering the plants.

Vegetation Roof: We didn't see any green on the roof. It was shown on the diagram of the building, but we couldn't see anything when we looked at the roof.

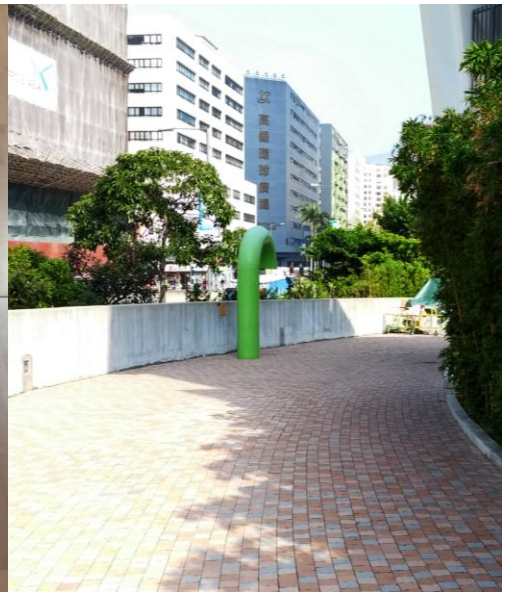
Biodiesel Generator: Yes, it was running and not under repair. The tour guide mentioned that there were complications with a certain component within the generator which would cause it to be off for long periods of time. This is because the part had to be ordered from Switzerland and shipped to Hong Kong. The generator is on display with a diagram showing where the electricity flows to and from. The digital display showing the energy produced since 2012 by the building read 33,144 kwh. The display showing the energy used since 2012 read 21,765.8 kwh.



Chilled Beam/Ceiling: None of the workers were using desk fans. Also, none of the ceiling fans were on, however this is likely because there was a breeze from the windows being open.

High Volume Low Speed Fan: There were two of these fans (not in use at the time because it was not hot enough) in the lobby of the building. During the summer they are used to increase the flow of natural ventilation throughout the building. Their design is unique as they use little energy to create a lot of wind.

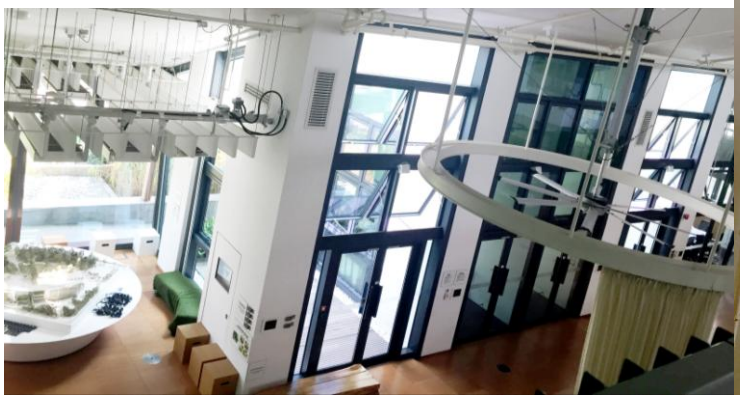
Thermal Temperature: The guide said they aim to keep the temperature at 25-26 degrees Celsius. We were all very comfortable in the building. There was a nice breeze everywhere.
Noise: We noticed the traffic noise outside with all the windows being open, however it did not seem to loud for the people working at their desks.
Wind Tunnel: The wind tunnel was aimed at the harbor and had a very strong breeze flowing through it.
AC: The tour guide said that the air conditioning was off.
Insects: We did not notice any insects and it didn't seem that this problem was preventing people from keeping their windows open.
Under Floor Displacement Cooling: Cold air is generated in the basement and spread throughout the building by vents in the floor.



Light Pipes: There were 2 light pipes, however they were in between the office space and hallway, so they were not providing direct light to either space. Both pipes were made from local recycled aluminum.

Wind catchers: Added natural ventilation to the main floor with fresh air from the roof.

Natural light: All wall space was maximized with windows and most of the shades were open providing a very nice amount of natural light to the building.




Dual-flush toilets: Two of the half flush buttons in the women's bathroom did not work, so the full flush button had to be utilized.

Urinals: They were comparable to regular urinals, not any differences.
External Shading: Vertical shading to help block extremely strong sun on the north-west.

Rainwater Harvesting System: The water is collected from the roof and collected in wetland area. This water is used for irrigation of some of the green space.

Curvature of Roof: The curvature of the roof helped to maximize rain water collection and solar panel performance. Implemented to reduce complaints of reflection of light into nearby high rise buildings.

Eco-Home: Upstairs there is a model green home. It demonstrates how green technologies can be used throughout a home.

External Temperature Monitoring Devices: This system monitors the outdoor temperature and is used to guide the settings for the indoor air temperature.

Access for persons with disability: Elevator, ramps, blind markings throughout the building.
Elevator: The elevator generates some power from the braking mode of the motor.

Energy Savings: 50-60% annually compared to the surrounding buildings.
Solar Panels: The feature produces energy and helps the building to achieve the zero carbon standard.