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LEED Buildings Certification: Description and Benefits

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Abstract

This report will summarize the key aspects of LEED building certification. The history of the LEED Certification System is outlined and why it is the most prevalent system in North America. Then the certification process is explained in detail focusing on each level of certification along with the point structure that determines the final certification level. LEED buildings in the Atlantic region will be examined to give the reader some perspective and application of the certification process. The actual energy efficiency of LEED certified buildings is evaluated and discussed. The numerous benefits of LEED certification are outlined including the energy performance, the "green" marketing aspect, and any other benefits.

1. Introduction: LEED Buildings

Leadership in Energy and Environmental Design (LEED) is a building rating system created by the United States Green Building Council (USGBC). The LEED rating system was created in order to encourage the construction and maintenance of sustainable buildings, as well as to increase the sustainability of existing buildings. The history of the LEED system will be explored, as well as how the LEED system has been adopted around the world. The LEED system in Canada will also be examined, along with how LEED has become the most popular sustainable building rating system in North America.

1.1. History of LEED

The USBGC was established in 1993 to encourage sustainability in the construction industry. At the first council meeting, the idea was set forth to create a green building rating system. In 2000, the LEED building rating system was revealed, and to this day has been the leading rating system not only in the United States, but also across the world.

In 1998, the first LEED pilot project was introduced. This was considered to be LEED version 1.0. When the official LEED system was introduced in 2000, it was named LEED v2.0. Over the years, there have been several different versions added to incorporate different types of projects, and to continuously improve on previous versions. Such changes are made to adapt to the changes to green buildings needs (i.e. life cycle analyses of new materials), revise the credit weighting to ensure that it is accurate, and to continuously increase emphasis on performance. The newest version of LEED certification is version 4 (v4). It applies to a wider range of building types, and urges the optimization of water use [1].

1.2. Different Green Building Rating Systems Worldwide

In addition to the LEED rating system, there are several different rating systems created by various committees. All of the Green Building Councils (GBCs) around the world are a part of an organization called the World Green Building Council, which comprises all of the established, emerging, and prospective GBCs. Currently there are a total of 72 members in the World GBC. Of these 72 members, there are 26 established councils. Each of the 72 World GBC members has their own standards and rating systems.

Other systems that are similar to LEED all have the same goal, which is to rate buildings in their energy performance. In North America, there are four (including LEED) common green building rating systems. The Living Building Challenge (LBC) is a system that was created by the International Living Future Institute. The Cascadia Green Building Council first launched the LBC in 2006. Another system called Green Globes Canada was created in the year 2000. Green Globes expanded to the United States in 2004. All of the green building rating systems are a result of the Building Research Establishment Environmental Assessment Methodology (BREEAM) being formed in the United Kingdom in the early 1990s. BREEAM is the oldest green building rating system still used today. With the exception of BREEAM, the three other rating systems are used in the United States and Canada.

When comparing the three different rating systems in North America, all are very similar with regard to which areas of a project are analyzed. All of the systems rate a project based on the five following areas: sustainable site, water, energy, health, and materials. It was determined that the LBC is the system with the most rigorous requirements, while the

Green Globe has the least harsh requirements [2]. The Green Globe however was initially designed for lower-budget projects, and therefore has the least cost associated with its certification [3].

The LEED system still is the most popular in North America compared to the other rating systems. This is due to the great amount of green marketing that is associated with the LEED system. LEED is also very popular around the world. With the partnership with the USGBC, 38 of the 72 global GBCs have implemented a version of LEED as a building rating system in order to represent and increase the relevancy of LEED across the world. This group of Green Building Councils is known as the LEED International Roundtable [1].

1.3. LEED Canada

The Canada Green Building Council (CaGBC) was formed in 2002 with the same goals as other GBCs. Since the CaGBC was formed, there have been 1178 green buildings constructed with LEED certification, and 151 existing buildings that have been converted to meet LEED operation and maintenance certification standards.

2. LEED Building Certification Process

In order for a building to obtain LEED accreditation, an auditing/certification process must be performed. The auditing process involves points being awarded to the project if a certain requirement is met. In this section of the paper, the crediting system will be explained, the main sections of LEED certification will be discussed, and the most popular requirements will be examined.

2.1. Credit System

There are several different types of point systems for the various types of projects seeking LEED accreditation. In total, there are six different LEED certification categories: New Construction and Major Renovations, Core and Shell Development, Existing Buildings, Commercial Interiors, Neighbourhood Development, and Homes [5].

As was mentioned, over the years there have been several different versions of LEED. The LEED system has been changing to continuously improve the crediting system. Below in Table 1 is an outline of the current version (v4) for the new construction and major renovation projects.

Table 1 Current certification categories for new construction projects (v4) [CaGBC].

Certification Category	Number of Possible Credits
Sustainable Sites	10
Water Efficiency	11
Energy & Atmosphere	33
Material & Resources	13
Indoor Environment Quality	16
Regional Priority	4
Innovation	6
Location and Transportation	16
Total	109

Table 1 above shows the four different levels of certification or 'brackets' currently used in LEED projects around the world. There is one other credit that must be awarded which falls under "integrative process" which brings the potential total credits to 110. In previous versions of LEED™ certification, the number of total credits was 69. Since the transition from version 2.2 to version 3.0 in 2009, the number of potential credits was increased to 100, with 10 extra points for innovation and regional bonus points. It is still sometimes unclear to many how and why the extra 31 points are distributed [4].

The current certification categories for the different types of projects varies slightly in the number of possible credits, however the total number of possible credits is the same for each; 110. There are also slight differences in the credit scoring system when it comes to the type of project, based on its application. For example, the New Construction and Major Renovations categories have slightly different crediting weights for schools, hospitals (healthcare) and warehouses. This is outlined in Table 2 below.

Table 2 Differences in the number of possible credits for water efficiency for a New Construction or Major Renovation project [1].

Type of Building	Possible number of credits for the water efficiency category
School	12
Hospitality	11
Healthcare	11
Retail	12
Warehouses and Distribution Centers	11

As can be seen, there are only slight differences between the types of building being built. Overall, there differences in the weighting of the points is not due to the insignificance of a certain area, rather the increased relevance of other credits.

2.2. LEED Certification

In order for a building to become LEED™ certified, the building has to undergo an auditing process in order to ensure that the building will meet the requirements for LEED certification. Depending on the type of project (i.e. new construction or existing building) the detailed auditing process may be slightly different, however the overall process is very similar.

When seeking LEED certification, there is a two-phase application process. The first stage requires a preliminary submission, which is submitted for comments. The second stage is the final submission, where the details of the project are to be disclosed. The two submissions shall include:

The LEED rating system that is being requested

- Project contact information

- Project narrative – including three design highlights
- LEED project checklist, including project credits and anticipated score
- Supporting documentation
- List of Credit Interpretation Rulings/Requests (CIRs)
- Project drawings, photos, and diagrams, including site plan, floor plan, etc.

Along with this information, the payment is required for the applicable fees. When the green building council has received the submission, the project will then be reviewed. Credits are not actually awarded until after the project has been built, to assure that the building has been built as it was designed (this confirmation is usually done through a third party). When the preliminary submission is reviewed, the auditor will place each credit into one of four categories: earned, denied, audited, or pending. The audited category simply means that the project coordinators will need to provide extra documentation to support a credit, while any credits placed under pending category will require technical clarifications in the final submission [4].

When the final submission is received and reviewed, the Green Building Council will provide the project coordinators with a Final LEED Review Report. This document outlines the credits awarded as well as the level of certification. The project coordinators do have the ability to appeal the GBC's decision if they do not agree with any credits that are awarded. A sample certification scorecard can be found in Appendix A. These scorecards are available on the USGBC and CAGBC websites for both pending and completed projects.

There are four different levels of LEED certification. From the highest to lowest level of certification: Platinum, Gold, Silver, and Certified. Table 3 below outlines the typical credit requirements for each level of certification for the newest version of LEED, v4.

Table 3 Typical credit Requirements for LEED v4.

Level of Certification	Required Number of Credits
Certified	40-49
Silver	50-59
Gold	60-79
Platinum	80+

Below in figure 2 are the four different seals of certification for the different certification levels.

Figure 1 – From left to right: LEED Certified, Silver, Gold and Platinum certification seals.

In Canada, the most popular level of LEED certification is gold, while the least popular is platinum. This is most likely due to the fact that that the gold certification has the largest bracket (20 credits). The cost to bring a LEED project from silver to gold is less than bringing a gold project to platinum certification.

In examining the most popular credits awarded to LEED projects, some suggest that the most popular credits do not contribute much to the energy conservation or efficiency of the building. It has also been suggested that the most popular credits are the credits that require the least amount of capital for a project. This suggests that the idea of having a 'green building' is more popular than having an energy efficient building. This paradigm is explored more in section 5.

3. LEED Buildings in the Atlantic Region

The LEED building certification program has been very successful since its beginnings in 1993. Different rating categories have been introduced and the overall certification program expanded. In 2010, 27696 buildings were registered for LEED certification and 5642 of these buildings have been approved for certification. [5] The majority of these building are located in the United States of America, which is apparent because that is the country of origin of the program.

LEED buildings have also reached the Atlantic region of Canada. Atlantic Canada's largest university, Dalhousie, has a sustainable building policy that was put in place in March 2011. The policy states that, "All new "major building projects" should be designed, constructed and certified to meet at least LEED Gold standards" where "A major building project is defined as a construction project larger than 10,000 gross square ft." [6] This policy is a positive step to ensure new constructions are built to high standards in energy efficiency and all other aspects of the LEED certification system.

A search on the Canadian Green Building Council website (www.cagbc.org) shows that 51 buildings are registered in Halifax, Nova Scotia for LEED certification. Of those 51 buildings, 16 have been certified. Of those buildings, one of notable mention is The Halifax Central Library which is in the certification process. On Dalhousie's Studley Campus, the Mona Campbell building has reached a Gold Certification Level in the rating system LEED Canada for New Construction and Major Renovation. As described in the previous section, there are four levels of certification; Certified, Silver, Gold, and Platinum. The only Platinum certified building in Halifax is the NS Power Office located on Lower Water Street. This section of the report will focus on these two buildings, the Mona Campbell building and The NS Power Office known as 1H. The aspects of the certification process as outlined in the previous section will be applied to these buildings along with interesting energy savings measures that were employed.

The Mona Campbell building was certified LEED Gold in June 2012 after its completion in September 2010. The building cost is 33 million dollars and the building is 101 303 square feet. [7] It achieved a total of 44 points, where the point range for gold certification is 39-41 points. The most interesting energy savings measure that was employed was BubbleDeck construction. This is a revolutionary concrete floor system that uses recycled plastic balls, 'void formers' placed in between a lattice of metal reinforcement. The concrete is then poured into the system to create a relatively light and strong floor and slab deck system. This construction is just the third application of BubbleDeck in North America. [Atlantic Green Building] The advantages of this system are reduced weight and decreased concrete use; 1 kg of recycled plastic is used in the system in place of 100 kg of concrete. [8]. This system results in a 30% decrease in the volume of concrete required for construction. [7] The construction techniques employed for this system also reduce costs and speed up the process. The entire system results in a savings of 2.5 % to 10 % for total construction. [8] This building technique would fall under the Materials and Resources section of LEED certification where the Mona Campbell building received 2 credits for using recycled content. On the penthouse walls the building uses a 200 square meter solar wall that preheats ventilation air, this process saves 15% of energy, particularly in the winter months when heating loads are increased. [7] The building also uses an efficient lighting system that employs occupancy sensors to detect if the room is being used and light sensors to adjust lights based on the amount of natural light available. The heating ventilation and air conditioning (HVAC) system employs heat pumps which result in a 55 % decrease in energy consumption. [7] This building received 5 of a possible 10 points in the Energy and Atmosphere category for "Optimize Energy Performance" where the use of energy efficient heat pumps would have contributed to this score, among many other aspects. To receive points for this section a dynamic building simulation is performed and the yearly energy costs are compared to a reference value. The reference value is determined by American Society of Heating, Refrigerating and Air-Conditioning Engineers ASHREA Standard 90.1. [5] The energy costs include service water heating, pumps, fans, space cooling, space heating and lighting. The inputs to this simulation are building location and weather data, building envelope specifications, occupancy information, HVAC system specifications, domestic water system and demands along with lighting control and efficiency. The Mona Campbell building simulation showed an energy consumption of 11.7 kWh/ft2/year which resulted in a 52 % energy savings in kWh and a 46 % energy cost savings. [9] This resulted in 5 LEED points in the category mentioned above. A LEED accredited professional was involved in several steps of the construction process which results in an additional point in the Innovation and Design process category.

Not all aspects of the building as they are related to the LEED certification process were discussed however the main points were explored. The Mona Campbell building is a great example of how the pursuit of LEED certification resulted in an energy efficient building using innovative green technology. The energy performance of the building was verified using a building model which can be compared to utility costs over the life span of the building. The Mona Campbell building is an example of a robust LEED project that produced not just a Gold certification but an energy efficient building with the use of innovative technology.

The only Platinum rated building in Atlantic Canada is the NS Power building on the Halifax waterfront. This innovative building, known as 1H is on the site where a coal fired generation station used to stand. The building occupancy is 600 and the approximate size is 14 600 gross square meters. [10] Gross area is defined as "The sum of all areas on all floors of a building included within the outside faces of its exterior walls, including all vertical penetration areas, for circulation and shaft areas that connect one floor to another." [11] To give you an idea of the size of the building, it is about 1.5 times larger, with regards to area, compared with the Mona Campbell Building. The building received a total of 52 points in the LEED Canada New Construction – 1.0 rating system where Platinum certified is achieved with 52 to 70 points. LEED certification was achieved on March 7, 2013. An interesting aspect of this construction was that existing beams and walls were used in the construction. The original metal framework that used to support coal bins and turbines was strong enough to support new floors. [10] This building employs the first major use of 'chilled beam' technology in Atlantic Canada for cooling of the building. This application of chilled beam technology uses cold seawater, instead of air, to transport cooling which lowers energy consumption. [10] Additionally, the building uses heat recovery in the HVAC system, variable speed drives (VSD) for fans, efficient and intelligently controlled lighting and an efficient building envelope. [10] This building received maximum points in the water efficiency category where water efficient landscaping, innovative wastewater technologies and water use reductions are all factored in. These efficiencies result in a 24 % decrease in water consumption compared with the reference building. [10] These energy saving technologies come as no surprise to a building that achieved Platinum certification.

There are many other aspects of the LEED certification process that look at energy use in a broader sense. LEED certification looks at the energy uses to arrive at the building. In the Sustainable Sites category the building received 2 points for having public transportation access and bicycle storage and changing rooms. These points show effort to help make it as easy as possible for the building occupants to use alternative transportation to arrive at 1H. In the same category, a point was received for the redevelopment of a contaminated site, which is related to, as mentioned above, that the site used to be a coal fired electricity generation station. Additionally, LEED certification looks at the materials used for construction. In the 1H project 28 % of the materials used for construction were sourced within an 800 km radius. [10] This resulted in 2 points in the Materials and Resources category of LEED certification for 20% of materials extracted and manufactured regionally. As discussed with the Mona Campbell building, points are also rewarded for use of recycled materials. 1H received 2 points for uses of 15 % use of recycled content where half is post-consumer and half is post-industrial. In the same category, points were awarded for construction waste management where 75 % of the waste was diverted form the landfill.

The 1H building achieved an energy intensity of 100 kWh/m2/year which results in an energy savings relative to the reference building of 48 % under the same ASHREA Standard 90.1. To compare with the Mona Campbell building 100 kWh/m2/year is equal to 9.29 kWh/ft2/year. The energy intensity of the Mona Campbell building is 11.7 kWh/ft2/year as determined by a dynamic simulation of the building. This shows that this Platinum rated building is more efficient compared with a Gold rated building. In the LEED category of Energy and Atmosphere and the sub category of Optimize Energy Performance, 1H received 10 out of a possible 10 points, twice what the Mona Campbell building received.

A Platinum rated LEED building is clearly superior to a Gold building, the comparison of 1H and the Mona Campbell building shows this clearly. The LEED certification system and how it is actually related to specific buildings was explored and compared between two buildings in Halifax, Nova Scotia. This shows that the system is robust and a very useful tool for developers to build energy efficient buildings that look at energy efficiency on a large scale and not just looking at what happens in the building envelope. As the system process is iterated and improved it is going to become the standard for energy efficient buildings and increase their density in cites around the world.

4. Actual Energy Savings of LEED Certified Buildings

In the previous section this paper two specific buildings in the downtown Halifax area were examined where their energy performance was related to the LEED certification system. In terms of energy management engineering, the most interesting aspect of the LEED certification is the points awarded in the Energy and Atmosphere category under Optimize Energy Performance. There are 10 points available in this sub-category. A dynamic building simulation is performed and compared to a simulation of a reference building as determined by ASHRAE Standard 90.1. The energy rating in the LEED system is then calculated based on the annual cost of energy for the building compared with the cost of the reference building. For a 20 % improvement compared with the baseline 2 points are awarded, and then an additional point for every 10 % above baseline for a maximum of 10 points. [12] Additionally, a total of 7 points are available for use of renewable energy, best practise commissioning, ozone protections, measurement and verification along with green power purchasing. The 10 points available for energy efficacy is the largest point sub-category in the LEED certification.

This section will review a study performed in 2006 titled, "Evaluating the energy performance of the first generation of LEED-certified commercial buildings". The review will examine the modeled design compared with the reference energy performance of 21 buildings and compare that with actual energy use from billed energy consumption. [13] Some of the reasons why the two might not agree is because of differences in design of the building and actual construction along with operation and maintenance issues that might change energy consumption. [13] It is useful to look at this data to see if the LEED certification system could be improved and to better understand the energy performance of these buildings.

The main part of this study is a table that presents the results of the study. The first column presents the modeled whole building in terms of energy intensity per square foot. The second column presents the modeled baseline building. The third column presents the ratio of the first two columns to show the difference between the two as an indicator of the energy savings. Along with that, the second last column show the LEED points received where 10 points is the maximum energy efficiency points. The mean ratio of modeled whole building to the baseline building is 73% which means a 27% increase in energy efficiency of the 21 LEED buildings in this study. The points received does not accurately reflect the energy efficiency. For example building ID #1 was 22% better than the modeled baseline but received 5 LEED points for energy efficiency when based on the system, when it should have received 2 points. Building ID #2 was 33% better than baseline and received 6 LEED points, when it should have received 4 points. Building ID #7 was 35% better than baseline and received 3 LEED points, when it should have received 4 points. This shows some disparity in the LEED points awarded and actual energy efficiency.

In general, the modeled energy use intensity (EUI) compares well with the billed data in this study. The fifth column shows the ratio of the actual whole building purchased from billed data to the modeled. This shows a mean of 99% showing that the two correlated very well. This is a very important aspect of the analysis showing that the modeled buildings are actually reflecting the billed energy.

This study was by no means complete; it was a very small sample size, 21 buildings, which represents 7% of the 300 LEED-NC buildings constructed at the time the study was performed. [12] The buildings for the study were not selected randomly; they are selected based on which buildings could offer the data necessary for the study. The study does show that LEED buildings are performing; the majority of the buildings were within 10% of their design values that shows quality of construction and quality of the certification system. [13] However, as described above, the LEED energy efficiency points that are awarded are not accurately reflecting the energy efficiency. The study was published in May 2006 and it is likely that the LEED certification process has improved since then.

This study starts the process of documenting the actual energy efficiency of LEED buildings. The energy efficiency points are the most significant points in the LEED certification. To improve the LEED system perhaps an extra point could be awarded for those buildings who offer to have all the pertinent energy information available to an independent researcher on behalf of LEED. The data that would be available would be billed energy, and it could be compared with the baseline and whole building model to see if it changes over time. This would help improve the system, it may help establish a timeframe under which buildings should be required to become re-certified.

5. Green Marketing Benefits of LEED Certification

With the adaptation of green and sustainable buildings, one would think that industry is moving towards buildings that perform better overall. This however, is not the only benefit to having a green building, as with the green building comes green marketing opportunities. It should be noted that the paradigm of green marketing is not limited to LEED, but all other certification systems. The case for green marketing only applies to buildings that have a consumer base, as there would be no marketing (in general) for a hospital or school with LEED certification.

5.1. Performance vs. Marketing Model

Green marketing is the marketing of products and or services that are environmentally favoured. The green marketing benefits of a LEED certified building come from the positive response from the consumer to the green certification. It has been argued that the green marketing benefits of a LEED building are the reason for implementing such standards rather than the actual reduced operating costs associated with a more energy efficient and environmentally friendly building. In order to evaluate these claims, the frequency of credits earned will be analyzed.

Below in figure 2, a histogram of the points earned in LEED certified projects is shown, along with the resulting certification level. It should be noted that these data were taken from an older version of LEED, as the brackets are slightly different (maximum number of points is approximately 69).

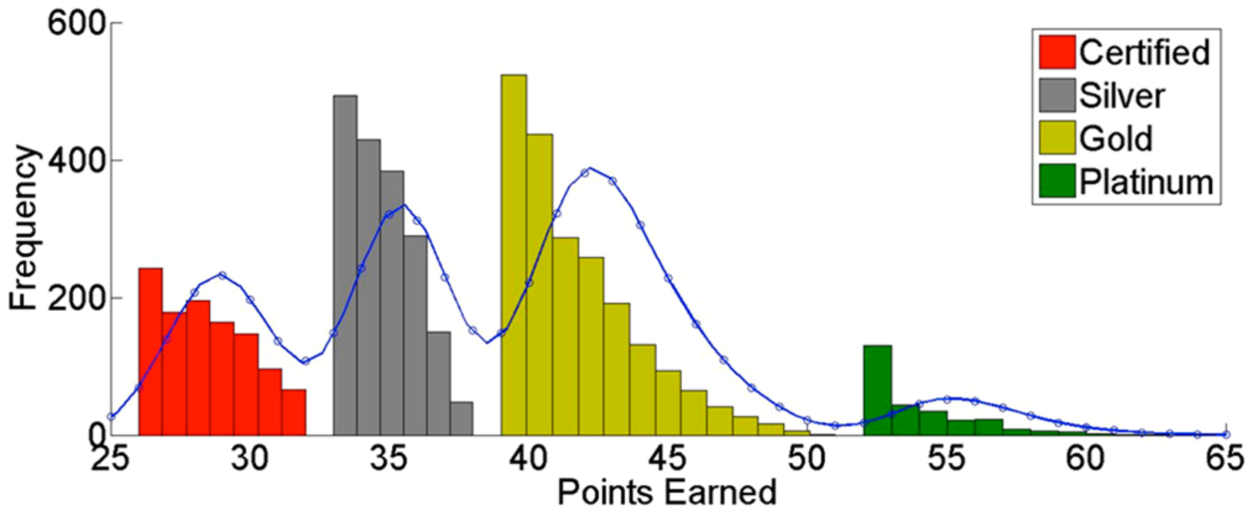

Figure 2 – Points Earned vs. Frequency of LEED certified projects [14].

As can be seen in figure 2 above, there seems to be a trend in the data, such that there is a higher frequency just above the threshold for any given certification level. For example, the frequency of projects just above the required number of credits for a given certification level is considerably higher than that just below a threshold. This suggests that the designers of a project are aiming for a certain level of accreditation instead of simply designing a more energy efficient, high-performance building.

Upon further analyses of the data, it was discovered that the majority of the platinum certified LEED buildings are non-profit organizations. It was also discovered that the majority of the non-profit organizations have projects that are just slightly above the threshold, while for-profit organizations (such as government or businesses) do not follow these patterns as regularly. It was also found that in the event that a project falls just below the threshold to the next level of certification, extra effort would be made in order to reach the next level of certification.

As can be seen in the histogram, there are several LEED projects that fall in the middle of a certification threshold. This is could be the result of two events; one being that the designers wanted to design a green building without worrying about the minimum certification level requirements. The other is that during the design phase, the designers had accounted for credits that they were unsure about, and as a result they had tried to obtain as many credits as possible. It is evident that green marketing does play a role in the construction of LEED projects, but the performance benefits to a green building are also present. Since there is sometimes extra effort made in reaching the next certification level, the building is sometimes 'greener' than it would be if the LEED thresholds did not exist.

5.2. Green Marketing Benefits

Besides the reduced energy and operation costs of a LEED certified building, there are several green marketing benefits that arise. Such green marketing benefits include an improved image, as being environmentally friendly, and the value of the properly is likely to rise if it is considered a green building; with the higher value, comes a higher resale value. Along with these benefits, there are usually tax incentives for constructing a green building. With these buildings comes the idea of a healthier building, which is attractive to workers. This is another benefit to operating a green building, as more people will want to work in the building [4].

6. Other benefits of LEED Certification

Likewise with the performance/operating cost benefits, as well as the increased 'green' marketability, there are also several more benefits to constructing and operating a green building. In this section, these benefits will be discussed.

6.1. Increased Employee/Tenant Health

With a LEED certified building, the quality of the interior environment is increased. The air quality is superior to that of a conventional building built to code, there is more effective noise reduction, and the lighting inside the building tends to be greater. The thermal control inside the building is more likely to be better controlled, resulting in the occupants being more comfortable when inside. The most important of these features is the air quality. A LEED building will result in less air-quality related health issues, such as Sick Building Syndrome (SBS). The improved air quality may also lead to fewer cases of cold and flu in the workplace. Table 4 below shows the reduction in work losses thanks to LEED buildings.

Table 4 Health improvements in LEED buildings [4].

Cause of Absence	Percent Reduction (%)
Communicable respiratory diseases	9-20 %
Reduced Allergies and Asthma	18-25 %
Nonspecific Health and Discomfort Issues	20-50 %

As can be seen in Table 4, all of these benefits of improved employee health will lead to increased productivity, as absenteeism will be reduced.

6.2. Increased Productivity

The increase in employee health is not the only means by which productivity increases, but it is thought to be responsible for approximately $10 to $30 billion in the United States [4]. It is thought that the indoor quality of LEED buildings will result in an increase in productivity, due to the fact that the employees are better off in a more comfortable workspace [4]. It is argued however that the increase is not significant and can be sometimes thought of as negligible [15].

If the employees are thought to be happier in a LEED building, the retention of such employees is greater. This means that there is a lower employee turnover rate, which could result in the employees being more productive, as less time is spent training new employees.

6.3. Indirect Benefits

Along with direct benefits such as lower operating costs and greater production, there are some indirect benefits for the owners that are also a result of the green building. With green buildings being more environmentally friendly, there is less of a need to rely on external power grids to function on a day-to-day basis. There is also less of a need to rely on the community providing the building with water, as the building is more water efficient. This "Self-Reliance" means that the building will not be affected as severely in the event of a power outage, or water shortage. In the event of an increase in the price of fuel or electricity, the building will not suffer as much as those that rely heavily on those resources. This is also an example of "Future-Proofing", which is securing the future of the building and its owners. The increased health and productivity of the occupants also secures the future of the LEED building, as the occupants are less likely to be litigious [4].

7. Conclusion

LEED and other green building certification systems are likely going to become more prevalent as energy efficiency of buildings becomes more important. LEED Buildings offer numerous benefits to the owner like "green" marketing opportunities, improved employee health, increased building air quality, energy efficiency leading to lower billed energy costs and many more. All the benefits create a very attractive investment for a business owner. The system is not perfect and it must continue to be a dynamic system. As building technology improves the points for energy efficiency might have to be reviewed. As new types buildings show a need for LEED certification, a new or modified certification system must be developed. To help with this dynamic system data must be collected from existing LEED buildings and evaluated. Overall the LEED system is robust and useful in the green building industry. In conclusion, LEED certification creates a simple, marketable tool for building owners to build a green building, enjoy the benefits and save on energy costs.

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Appendix A LEED Scorecards

LEED v4 for BD+C: New Construction and Major Renovation

Project Checklist

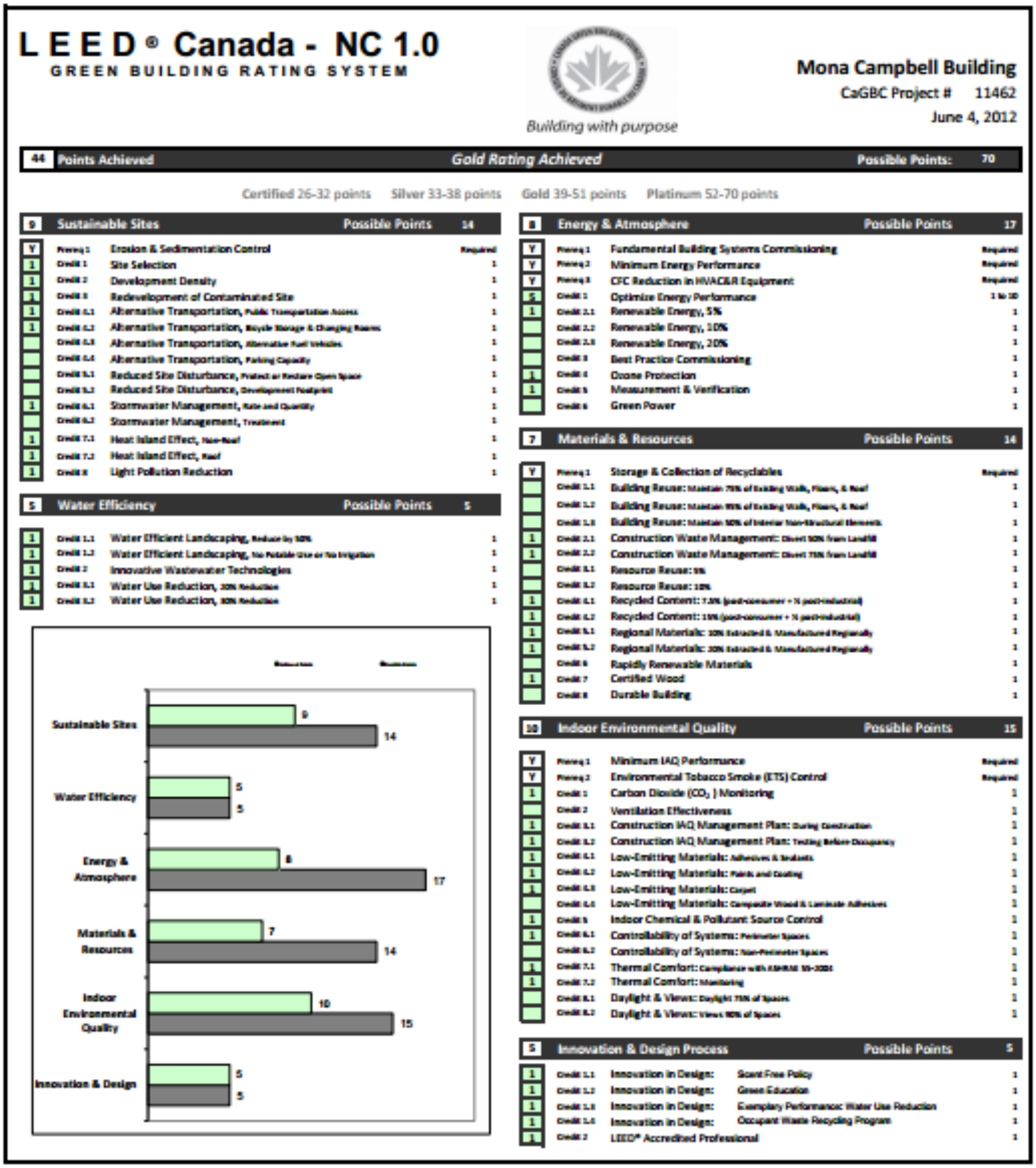
Y	?	N			
			Credit	Integrative Process	1
0	**0**	**0**		**Location and Transportation**	**16**
			Credit	LEED for Neighborhood Development Location	16
			Credit	Sensitive Land Protection	1
			Credit	High Priority Site	2
			Credit	Surrounding Density and Diverse Uses	5
			Credit	Access to Quality Transit	5
			Credit	Bicycle Facilities	1
			Credit	Reduced Parking Footprint	1
			Credit	Green Vehicles	1
0	**0**	**0**		**Sustainable Sites**	**10**
Y			Prereq	Construction Activity Pollution Prevention	Required
			Credit	Site Assessment	1
			Credit	Site Development - Protect or Restore Habitat	2
			Credit	Open Space	1
			Credit	Rainwater Management	3
			Credit	Heat Island Reduction	2
			Credit	Light Pollution Reduction	1
0	**0**	**0**		**Water Efficiency**	**11**
Y			Prereq	Outdoor Water Use Reduction	Required
Y			Prereq	Indoor Water Use Reduction	Required
Y			Prereq	Building-Level Water Metering	Required
			Credit	Outdoor Water Use Reduction	2
			Credit	Indoor Water Use Reduction	6
			Credit	Cooling Tower Water Use	2
			Credit	Water Metering	1
0	**0**	**0**		**Energy and Atmosphere**	**33**
Y			Prereq	Fundamental Commissioning and Verification	Required
Y			Prereq	Minimum Energy Performance	Required
Y			Prereq	Building-Level Energy Metering	Required
Y			Prereq	Fundamental Refrigerant Management	Required
			Credit	Enhanced Commissioning	6
			Credit	Optimize Energy Performance	18
			Credit	Advanced Energy Metering	1
			Credit	Demand Response	2
			Credit	Renewable Energy Production	3
			Credit	Enhanced Refrigerant Management	1
			Credit	Green Power and Carbon Offsets	2

Project Name:
Date:

0	0	0	**Materials and Resources**		**13**
Y			Prereq	Storage and Collection of Recyclables	Required
Y			Prereq	Construction and Demolition Waste Management Planning	Required
			Credit	Building Life-Cycle Impact Reduction	5
			Credit	Building Product Disclosure and Optimization - Environmental Product Declarations	2
			Credit	Building Product Disclosure and Optimization - Sourcing of Raw Materials	2
			Credit	Building Product Disclosure and Optimization - Material Ingredients	2
			Credit	Construction and Demolition Waste Management	2
0	0	0	**Indoor Environmental Quality**		**16**
Y			Prereq	Minimum Indoor Air Quality Performance	Required
Y			Prereq	Environmental Tobacco Smoke Control	Required
			Credit	Enhanced Indoor Air Quality Strategies	2
			Credit	Low-Emitting Materials	3
			Credit	Construction Indoor Air Quality Management Plan	1
			Credit	Indoor Air Quality Assessment	2
			Credit	Thermal Comfort	1
			Credit	Interior Lighting	2
			Credit	Daylight	3
			Credit	Quality Views	1
			Credit	Acoustic Performance	1
0	0	0	**Innovation**		**6**
			Credit	Innovation	5
			Credit	LEED Accredited Professional	1
0	0	0	**Regional Priority**		**4**
			Credit	Regional Priority: Specific Credit	1
			Credit	Regional Priority: Specific Credit	1
			Credit	Regional Priority: Specific Credit	1
			Credit	Regional Priority: Specific Credit	1
0	0	0	**TOTALS**	Possible Points:	**110**

Certified: 40 to 49 points, **Silver:** 50 to 59 points, **Gold:** 60 to 79 points, **Platinum:** 80 to 110

Mona Campbell Building Scorecard – Gold Certified



LEED® Canada - NC 1.0
GREEN BUILDING RATING SYSTEM

Building with purpose

Mona Campbell Building
CaGBC Project # 11462
June 4, 2012

44 Points Achieved — *Gold Rating Achieved* — Possible Points: 70

Certified 26-32 points Silver 33-38 points Gold 39-51 points Platinum 52-70 points

9	Sustainable Sites		Possible Points 14
Y	Prereq 1	Erosion & Sedimentation Control	Required
1	Credit 1	Site Selection	1
1	Credit 2	Development Density	1
1	Credit 3	Redevelopment of Contaminated Site	1
1	Credit 4.1	Alternative Transportation, Public Transportation Access	1
1	Credit 4.2	Alternative Transportation, Bicycle Storage & Changing Rooms	1
	Credit 4.3	Alternative Transportation, Alternative Fuel Vehicles	1
	Credit 4.4	Alternative Transportation, Parking Capacity	1
	Credit 5.1	Reduced Site Disturbance, Protect or Restore Open Space	1
	Credit 5.2	Reduced Site Disturbance, Development Footprint	1
1	Credit 6.1	Stormwater Management, Rate and Quantity	1
	Credit 6.2	Stormwater Management, Treatment	1
1	Credit 7.1	Heat Island Effect, Non-Roof	1
1	Credit 7.2	Heat Island Effect, Roof	1
1	Credit 8	Light Pollution Reduction	1

5	Water Efficiency		Possible Points 5
1	Credit 1.1	Water Efficient Landscaping, Reduce by 50%	1
1	Credit 1.2	Water Efficient Landscaping, No Potable Use or No Irrigation	1
1	Credit 2	Innovative Wastewater Technologies	1
1	Credit 3.1	Water Use Reduction, 20% Reduction	1
1	Credit 3.2	Water Use Reduction, 30% Reduction	1

8	Energy & Atmosphere		Possible Points 17
Y	Prereq 1	Fundamental Building Systems Commissioning	Required
Y	Prereq 2	Minimum Energy Performance	Required
Y	Prereq 3	CFC Reduction in HVAC&R Equipment	Required
5	Credit 1	Optimize Energy Performance	1 to 10
1	Credit 2.1	Renewable Energy, 5%	1
	Credit 2.2	Renewable Energy, 10%	1
	Credit 2.3	Renewable Energy, 20%	1
	Credit 3	Best Practice Commissioning	1
1	Credit 4	Ozone Protection	1
1	Credit 5	Measurement & Verification	1
	Credit 6	Green Power	1

7	Materials & Resources		Possible Points 14
Y	Prereq 1	Storage & Collection of Recyclables	Required
	Credit 1.1	Building Reuse: Maintain 75% of Existing Walls, Floors, & Roof	1
	Credit 1.2	Building Reuse: Maintain 95% of Existing Walls, Floors, & Roof	1
	Credit 1.3	Building Reuse: Maintain 50% of Interior Non-Structural Elements	1
1	Credit 2.1	Construction Waste Management: Divert 50% from Landfill	1
1	Credit 2.2	Construction Waste Management: Divert 75% from Landfill	1
	Credit 3.1	Resource Reuse: 5%	1
	Credit 3.2	Resource Reuse: 10%	1
1	Credit 4.1	Recycled Content: 7.5% (post-consumer + ½ post-industrial)	1
1	Credit 4.2	Recycled Content: 15% (post-consumer + ½ post-industrial)	1
1	Credit 5.1	Regional Materials: 10% Extracted & Manufactured Regionally	1
1	Credit 5.2	Regional Materials: 20% Extracted & Manufactured Regionally	1
	Credit 6	Rapidly Renewable Materials	1
1	Credit 7	Certified Wood	1
	Credit 8	Durable Building	1

10	Indoor Environmental Quality		Possible Points 15
Y	Prereq 1	Minimum IAQ Performance	Required
Y	Prereq 2	Environmental Tobacco Smoke (ETS) Control	Required
1	Credit 1	Carbon Dioxide (CO_2) Monitoring	1
	Credit 2	Ventilation Effectiveness	1
1	Credit 3.1	Construction IAQ Management Plan: During Construction	1
1	Credit 3.2	Construction IAQ Management Plan: Testing Before Occupancy	1
1	Credit 4.1	Low-Emitting Materials: Adhesives & Sealants	1
1	Credit 4.2	Low-Emitting Materials: Paints and Coating	1
1	Credit 4.3	Low-Emitting Materials: Carpet	1
	Credit 4.4	Low-Emitting Materials: Composite Wood & Laminate Adhesives	1
1	Credit 5	Indoor Chemical & Pollutant Source Control	1
1	Credit 6.1	Controllability of Systems: Perimeter Spaces	1
	Credit 6.2	Controllability of Systems: Non-Perimeter Spaces	1
1	Credit 7.1	Thermal Comfort: Compliance with ASHRAE 55-2004	1
1	Credit 7.2	Thermal Comfort: Monitoring	1
	Credit 8.1	Daylight & Views: Daylight 75% of Spaces	1
	Credit 8.2	Daylight & Views: Views 90% of Spaces	1

5	Innovation & Design Process			Possible Points 5
1	Credit 1.1	Innovation in Design:	Scent Free Policy	1
1	Credit 1.2	Innovation in Design:	Green Education	1
1	Credit 1.3	Innovation in Design:	Exemplary Performance: Water Use Reduction	1
1	Credit 1.4	Innovation in Design:	Occupant Waste Recycling Program	1
1	Credit 2	LEED® Accredited Professional		1

NS Power 1H Building Scorecard – Platinum Certified

LEED® Canada - NC 1.0

GREEN BUILDING RATING SYSTEM

Building with purpose

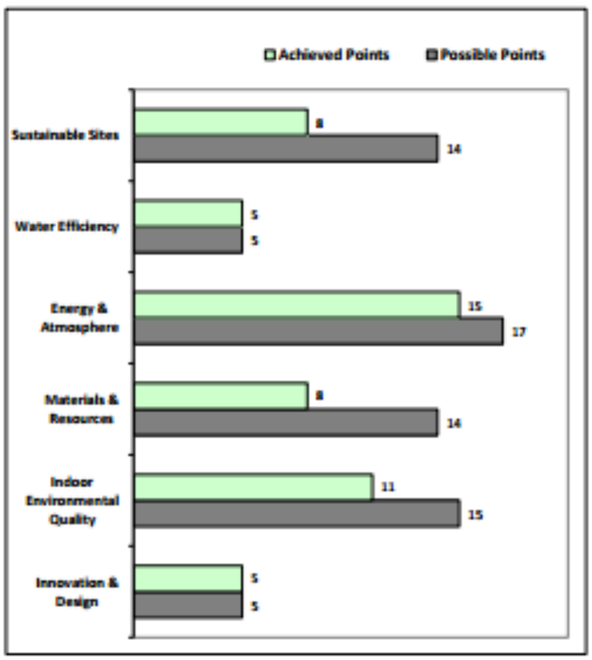
NS Power Office 130227
CaGBC Project # 11471
March 7, 2013

52	Points Achieved	*Platinum Rating Achieved*	Possible Points:	70

Certified 26-32 points Silver 33-38 points Gold 39-51 points Platinum 52-70 points

8	Sustainable Sites		Possible Points 14
Y	Prereq 1	Erosion & Sedimentation Control	Required
1	Credit 1	Site Selection	1
1	Credit 2	Development Density	1
1	Credit 3	Redevelopment of Contaminated Site	1
1	Credit 4.1	Alternative Transportation, Public Transportation Access	1
1	Credit 4.2	Alternative Transportation, Bicycle Storage & Changing Rooms	1
	Credit 4.3	Alternative Transportation, Alternative Fuel Vehicles	1
	Credit 4.4	Alternative Transportation, Parking Capacity	1
	Credit 5.1	Reduced Site Disturbance, Protect or Restore Open Space	1
	Credit 5.2	Reduced Site Disturbance, Development Footprint	1
1	Credit 6.1	Stormwater Management, Rate and Quantity	1
	Credit 6.2	Stormwater Management, Treatment	1
1	Credit 7.1	Heat Island Effect, Non-Roof	1
1	Credit 7.2	Heat Island Effect, Roof	1
	Credit 8	Light Pollution Reduction	1

5	Water Efficiency		Possible Points 5
1	Credit 1.1	Water Efficient Landscaping, Reduce by 50%	1
1	Credit 1.2	Water Efficient Landscaping, No Potable Use or No Irrigation	1
1	Credit 2	Innovative Wastewater Technologies	1
1	Credit 3.1	Water Use Reduction, 20% Reduction	1
1	Credit 3.2	Water Use Reduction, 30% Reduction	1



15	Energy & Atmosphere		Possible Points 17
Y	Prereq 1	Fundamental Building Systems Commissioning	Required
Y	Prereq 2	Minimum Energy Performance	Required
Y	Prereq 3	CFC Reduction in HVAC&R Equipment	Required
10	Credit 1	Optimize Energy Performance	1 to 10
1	Credit 2.1	Renewable Energy, 5%	1
	Credit 2.2	Renewable Energy, 10%	1
	Credit 2.3	Renewable Energy, 20%	1
1	Credit 3	Best Practice Commissioning	1
1	Credit 4	Ozone Protection	1
1	Credit 5	Measurement & Verification	1
1	Credit 6	Green Power	1

8	Materials & Resources		Possible Points 14
Y	Prereq 1	Storage & Collection of Recyclables	Required
	Credit 1.1	Building Reuse: Maintain 75% of Existing Walls, Floors, & Roof	1
	Credit 1.2	Building Reuse: Maintain 95% of Existing Walls, Floors, & Roof	1
	Credit 1.3	Building Reuse: Maintain 50% of Interior Non-Structural Elements	1
1	Credit 2.1	Construction Waste Management: Divert 50% from Landfill	1
1	Credit 2.2	Construction Waste Management: Divert 75% from Landfill	1
	Credit 3.1	Resource Reuse: 5%	1
	Credit 3.2	Resource Reuse: 10%	1
1	Credit 4.1	Recycled Content: 7.5% (post-consumer + ½ post-industrial)	1
1	Credit 4.2	Recycled Content: 15% (post-consumer + ½ post-industrial)	1
1	Credit 5.1	Regional Materials: 10% Extracted & Manufactured Regionally	1
1	Credit 5.2	Regional Materials: 20% Extracted & Manufactured Regionally	1
	Credit 6	Rapidly Renewable Materials	1
1	Credit 7	Certified Wood	1
1	Credit 8	Durable Building	1

11	Indoor Environmental Quality		Possible Points 15
Y	Prereq 1	Minimum IAQ Performance	Required
Y	Prereq 2	Environmental Tobacco Smoke (ETS) Control	Required
	Credit 1	Carbon Dioxide (CO_2) Monitoring	1
1	Credit 2	Ventilation Effectiveness	1
1	Credit 3.1	Construction IAQ Management Plan: During Construction	1
1	Credit 3.2	Construction IAQ Management Plan: Testing Before Occupancy	1
1	Credit 4.1	Low-Emitting Materials: Adhesives & Sealants	1
1	Credit 4.2	Low-Emitting Materials: Paints and Coating	1
1	Credit 4.3	Low-Emitting Materials: Carpet	1
1	Credit 4.4	Low-Emitting Materials: Composite Wood & Laminate Adhesives	1
1	Credit 5	Indoor Chemical & Pollutant Source Control	1
	Credit 6.1	Controllability of Systems: Perimeter Spaces	1
	Credit 6.2	Controllability of Systems: Non-Perimeter Spaces	1
1	Credit 7.1	Thermal Comfort: Compliance with ASHRAE 55-2004	1
1	Credit 7.2	Thermal Comfort: Monitoring	1
1	Credit 8.1	Daylight & Views: Daylight 75% of Spaces	1
	Credit 8.2	Daylight & Views: Views 90% of Spaces	1

5	Innovation & Design Process		Possible Points 5
1	Credit 1.1	Innovation in Design: Green Building Education	1
1	Credit 1.2	Innovation in Design: Green Housekeeping Program	1
1	Credit 1.3	Innovation in Design: Low Mercury Lamps	1
1	Credit 1.4	Innovation in Design: Low-Emitting Furniture Systems	1
1	Credit 2	LEED® Accredited Professional	1

Table 2 from reference [13] showing the main results from the study titled Evaluating Energy Performance in First Generation LEED-Certified Commercial Buildings. This table is referred to in section 4 where the actual energy savings of LEED certified buildings is explored

Table 2. Modeled and Actual Site Energy Consumption, with Energy Star Ratings and LEED Energy Points for the 21 LEED-NC Buildings in this Study

ID#	Modeled Whole Building Design [KBtu/f²-yr]	Modeled Whole Building Basecase [KBtu/f²-yr]	Modeled Design/ Basecase [%]	Actual Whole Building Purchased [KBtu/f²-yr]	Actual Whole Building Purchased /Modeled [%]	Energy Star Score	LEED Energy Efficiency Points	Total LEED Energy Points
1	63	81	78	47	75	82	5	6
2	76	114	67	52	68	81	6	9
3	35	54	65	61	174	69	4	5
4	66	95	69	98	148	NA	3	6
5	154[b]	212	73	48	--	64	3	4
6	69	94	73	48	70	57	4	7
7	56	86	65	44	79	66	3	5
8	68	89	76	78	115	17[c]	4	6
9	52	77	68	48	93	95	4	6
10	168	205	82	158	94	2[c]	4	5
11	69	89	78	69	100	72	4	8
12	79	--	--	73	92	52	0	1
13	125	172	73	22	18	99	2	3
14	113 total	157	72					
14[a]	66 purchased		--	70	62	64	10	14
15	265	127	87	128	48	7[c]	1	4
16	171[b] total	219	78			NA	3	
16[a]	162 purchased			507	--	NA	3	6
17	353			357	101	NA	--	--
18	267	496	54	271	101	NA	2	3
19	149[b]	208	72	290	--	NA	3	6
20	27	32	84	33	123	55	2	2
21	46			103	225	16[c]	--	--
N	18	18	17	21	18	12	19	19
Mean	111	145	73	124	99	71	3.5	5.6
Med.	69	105	73	70	94	68	3	6
SD	90	102	8	124	46	14	2	3
Min.	27	32	54	22	18	52	0	1
Max.	353	496	87	507	225	99	10	14

[a]These buildings have on-site PV, so their total and purchased are different.

[b]These buildings have only the regulated end-uses in the model, not whole building.

[c]Energy Star doesn't account for the large plug loads in these buildings, so their totals are not included in the average.