AN ANALYSIS OF GREEN BUILDING RATING SYSTEMS IN THE CONTEXT OF HISTORIC PRESERVATION

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By

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ABSTRACT

This essay analyzes the application of green-building rating systems to historic structures. It aims to understand the advantages and/or disadvantages of the different rating systems in use such as LEED, BREEAM and SKA, when used for a historic structure. It shows that while some systems are a little more flexible to accommodate the specific requirements of a historic structure, there is, nevertheless, a need for a green-building rating system aimed specifically at implementing strategies for achieving increased sustainable use of a historic structure.

The study is done by analyzing and comparing data from the Fernow Hall LEED certification project at Cornell University with the requirements of two other systems, BREEAM and SKA.

BIOGRAPHICAL SKETCH

Rashmi Gajare is an architect from India and has Master's degrees in French as well as Indology (study of ancient India). She enjoys learning new languages and scripts such as ancient Brahmi, Modi and at present, Tibetan. She has worked on the BORI Manuscript Museum project in the past and also as a volunteer on various archaeological digs for the Indus Valley Civilization period.

During her design practice in India, she focused on designing interiors and was responsible for liaising with clients, conceptualizing and finalizing designs, communicating with executing agencies and working on financial estimates. In the field of historic preservation, she worked on a temple conservation project in Pune. Her overall design philosophy is based on finding creative solutions with innovative thinking and resourcefulness while acknowledging the long-term financial viability of a project.

She is a LEED Accredited Professional (BD+C) since 2015 and is excited at the possibility of combining the two fields of historic preservation and sustainable architecture. Her interest in the application of technology to the field of Preservation is an avenue that she wants to explore further in the future. Her plans include disseminating the knowledge gained at Cornell University and creating local applications for the systems used in the USA. One of her aims is to work for creating a database of the heritage properties in India by encouraging local participation in the process.

To my parents.

Keshar Ravindra Gajare

from whom I get my love for learning,

and Ravindra Lala Gajare

for unconditional support

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INTRODUCTION

Historic Preservation aims to safeguard our cultural heritage for future generations. Moreover, a well-known definition of Sustainable Development states is development that meets the needs of the present without compromising the ability of the future generations to meet their own needs.[1]

The building industry is a large consumer of natural resources. It has been estimated that in the United States, about 30 percent of all raw materials usage is in the construction industry[2] and that it can take, according to a recent report by the Preservation Green Lab, anywhere from 10 to 80 years[3] to make up for the adverse environmental impacts of demolition of an old building and construction of a new one, even if the new structure is energy efficient. Furthermore, it has been said that the most sustainable building is the one that has already been built. Thus the fields of Historic Preservation and Sustainable Design appear to be natural allies.

There have been some studies on this topic, such as Jennifer Lynn Buddenborg's 2006 Master's Thesis at Cornell University titled "Changing Mindsets: Sustainable Design in Historic Preservation" in which she states that the way for sustainable design and historic preservation to work together is by changing the mindsets of the practitioners in both the fields.[4] A report by Preservation Green Lab[5], as mentioned earlier, has attempted to quantify the time period needed for a new building to recover its impact on the environment by using case-study buildings for both renovation and new construction.

The recognition of the need to alleviate impacts of the building industry on the environment has given rise to many of the green-building rating systems around the world.

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[1] ((WCED) 1987) Also known as the Brundtland Commission after its Chairman Gro Harlem Brundtland, Overview.I.3.

[2] (USGBC, LEED n.d.)

[3] (Preservation Green Lab 2011), 84.

[4] (Buddenborg 2006), 125-131. The LEED system used for analysis for this study was LEED NC V2.1 (2005). The present version in use is LEEDv4 (2013)

[5] Preservation Green Lab is a programmatic office of the National Trust for Historic Preservation working to research community value of historic preservation and pioneers policy solutions to encourage greening of historic buildings.

These systems, such as LEED and BREEAM, attempt to make the process of applying green principles to a building efficient and standardized. There have been many points of criticism with some such systems. For instance, that they focus more on new construction and the use of new products. Another argument is that these systems place more emphasis on the annual energy savings of a structure, new or old, when some experts suggest that the embodied energy of an existing building is about 15 to 30 times the annual energy usage.[6]

This study is done with the understanding that all systems have their strengths and weaknesses and the way to improve a system is through, firstly, acknowledging the lacunae and then to learn from other success stories. To this effect, this report will analyze the way in which some of the green-building rating systems from different parts of the world interact with overall Historic Preservation objectives.

The thesis begins by researching the terms, "Sustainability" and "Quantification" as well an overview of the Quantification systems in use. This is followed by a look at the intersection of the fields of Historic Preservation and Sustainable design. For this purpose, three chosen Rating Systems are studied and analyzed for their application to historic structures. The data from the case study of Fernow Hall, a historic structure with a LEED Gold rating at Cornell University, is used for this purpose.

The report has the following outline. Chapter one discusses the term 'Sustainability' by looking at the various definitions of the term over time and geography through an overview of the history of Sustainability as understood in the modern times.

Chapter Two considers various quantification methods in the field of sustainability with an emphasis on sustainability indicators. These indicators, in turn, can be seen reflected in the various quantification systems.

Chapter Three delves into the field of Green-building Rating systems, starting with background information for some of the systems used around the world such as LEED, BREEAM, HQE and so on. It

[6] (Lubek 2010), xiii.

discusses the methodology behind theses certifications and way they are scored. It will also discuss the rating system's focus on Historic Preservation.

Chapter Four analyzes the LEED certification data for the Colonial Revival, early 19th century Fernow Hall at Cornell University. The building is listed on the National Register of Historic Places and was awarded LEED Gold certification in 2014. The ease of accessibility to the professionals that worked on this project as well as of the data used for the LEED certification was one of the important reasons for the choice of case study.

In Chapter Five, this data is used to evaluate how Fernow Hall would fare when the other Green-building Rating systems are applied to it. The analysis is expected to generate a framework and give guidelines as to which aspects of a green-building rating system works especially well with Historic Structures.

Finally, in the conclusion, this report discusses the results of the case study analyses in Chapters four and five. This report aims to present some perspective on the issue of the Sustainability of Historic Structures by taking a look at the best practices as undertaken by the various Green-building Rating systems in conjunction to their application to Historic Structures.

CHAPTER 1: DEFINING SUSTAINABILITY

1.1. INTRODUCTION

This chapter will discuss the term 'Sustainability' by looking at various definitions of the term over time and geography through an overview of the history of Sustainability as understood at present.

In his 2010 book 'Green Restorations: Sustainable Building and Historic Homes', Aaron Lubek[7] states quite simply that 'Sustainability is the pursuit of longevity'. It is a concept that is as new-age as it is old. Before the advent of the age of industrialization, sustainable living was a matter of necessity for common people. Resources extraction was not as advanced nor was transportation. Thus, using local resources for maximum utilization along with actions to ensure their supply in the future was a natural path to take. A good example of this was the practice of using rainwater harvesting tanks as seen in Ahmedabad, India under its historic homes. These were invaluable to ensure water supply during the extremely hot and dry summer months. It is with new technological advancements that mankind seems to have lost its way and seems to think all problems can be solved through newer and better technology. The world now pursues a new version of Sustainability, one that tries to straddle two seemingly disparate concepts, simpler living and technological progress.

This chapter will focus on examining the concepts of Sustainability, Sustainable Development, Consumption and Production with respect to the exploitation of natural resources, as well as a brief exploration of the ideas of Reuse, Reduce and Recycle as applicable to the built environment. For this purpose, I will present some definitions of the word 'Sustainability' as put forth at various fora and examine the history of the modern conservation movement, around the world as well as in the US.

[7] (Lubek 2010), 7.

1.2. ‘SUSTAINABILITY’ AROUND THE WORLD

1.2.1. DEFINITION

Sustainability has been discussed by many experts over the years with attempts to define the concept. In his 1864 book ‘Man and Nature’, G.P. Marsh stated that, ‘Sustainability is based on the premise that everything that humans require for their survival and well-being depends, directly or indirectly, on the natural environment.[8]

The US government’s environmental policy as put forth in the 2009 Executive Order 13514 defines Sustainability as one that ‘creates and maintains conditions, under which humans and nature can exist in productive harmony, that permit fulfilling the social, economic, and other requirements of present and future generations’.[9]

Marsh’s definition of Sustainability acknowledges the fact that a high quality environment that provides clean and sufficient air, water and resources such as food and fuel, is necessary for overall human well-being. Some other resources that are necessary for modern human life are energy sources such as oil, timber and coal. All these can be categorized into two categories, renewable or non-renewable resources. The demand for resource consumption is steady but a non-renewable resource might not last forever and might need to be replaced with a renewable resource for sustainable living.

The US Environmental Protection Agency (EPA), in its 2011 report ‘Sustainability and the US EPA’ further adds that sustainability is “both a process and a goal to ensure long-term human well-being that does not threaten the continued availability of critical natural resources.” It is an iterative endeavor that needs to continuously course-correct as new data is collected and as our understanding of the world improves.

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[8] (Marsh 1965)

[9] (Executive Order 13514; Federal Leadership in Environmental, Energy, and Economic Performance 2009), 14.

1.2.2. SUSTAINABLE DEVELOPMENT

The inclusion of the social and economic factors that govern a society are also reflected in the definition of the term 'Sustainable Development' put forth in the iconic document 'Our Common Future' that was presented at the World Commission on Environment and Development (WCED) in 1987 (Brundlant Commission). It states, 'Sustainable development should meet the needs of the present without compromising the ability of the future generations to meet their own needs." Later, in 1992, the Rio Declaration at the United Nations Conference on Environment and Development in Rio de Janeiro (UNCED)[10] put forth a global plan of action for the cause of sustainable development and published a set of 21 principles known as 'Agenda 21'.

This was followed by subsequent global meetings, conferences and programs on sustainable development such as the Millennium Declaration (UN 2000), the Johannesburg Plan of Implementation at the World Summit on Sustainable Development (UN 2002) and finally, commemorating the 10th anniversary of the original Rio Declaration, the UN Conference on Sustainable Development met in Rio de Janeiro in June 2012. All these gatherings reiterated the emphasis on both the words 'sustainable' and 'development' at the same time which denotes a continual acknowledgment of the fact that development is inevitable and even desirable for society in general and that it is up to us to ensure that we put in mechanisms that promulgate sustainable choices and decisions.

1.2.3. SUSTAINABLE CONSUMPTION AND PRODUCTION

The exhaustion of non-renewable natural resources is a non-reversible process. The Johannesburg Plan of Implementation (UN 2002) calls,

> *to accelerate the shift towards sustainable consumption and production to promote social and economic development within the carrying capacity of ecosystems by addressing and, where appropriate, delinking economic growth and environmental*

[10] (United Nations General Assembly 1992), 1.

degradation through improving efficiency and sustainability in the use of resources and production processes and reducing resource degradation, pollution and waste.[11]

This idea of de-linking of economic growth, which can also be another word for development and environmental degradation, reiterates the importance of developmental criteria in policy making.

1.2.4. '3R INITIATIVE`

The idea of sustainable consumption and production, as put forth by the 2002 Johannesburg Plan of Implementation, is simplified in the '3R Initiative' that was proposed by Japan and ratified by the US at the G8 Sea Island Summit in 2004. It promotes the concept of the '3Rs' (Reduce, Reuse and Recycle) with the aim of reducing waste by making the right consumption choices (e.g. proper packaging materials), reusing and ultimately, at the end of their useful life, recycling resources. In 2008, Japan went a step ahead and announced a plan for accelerating the establishment of 'Sound Material-Cycle Societies' internationally, in which the maximum possible natural resources will be conserved and the environmental load reduced to as great an extent as possible by using the 3Rs principle.[12]

1.3. SUSTAINABILITY IN THE US

1.3.2. HISTORY

Roosevelt told Congress in 1907, "We must maintain for our civilization the adequate material basis without which that civilization cannot exist. We must show foresight, we must look ahead."[13] His words seem to echo the ideals of 'Sustainability'

The first National Parks in the United States were established in the early 1900s by Roosevelt, also known as the "conservation president". The rise of the 'sustainability' consciousness in the US could be a response to the destruction of its virgin forests by excessive logging and land conversion to

[11] (United Nations 2002), 7 (III.15)
[12] (Shunichi Honda 2013), 3.
[13] (Agency, Committee on Incorporating Sustainability in the U.S. Environmental Protection 2011), 17.

agricultural purposes as well as irreversible losses of certain wildlife, such as the extinction of the passenger pigeon. The activist movements of the 1960s and the 1970s rejected the post-World War II urban renewal programs for their destruction of natural resources. Rachel Carson's 1962 book, 'Silent Spring' remains a must-read on the subject of environmental degradation due to human actions. It described the overarching ill-effects of pesticides on animal life including human beings.[14]

The National Environmental Policy Act of 1969 (NEPA) was the first major US federal environmental law and it stated that it is the government's responsibility to "fulfill the responsibilities of each generation as trustee of the environment for succeeding generations".[15]

The heightened public opinion fueling the conservation movement accelerated after the oil embargo of the 1970s. Another important event in this decade was the formation of the Environmental Protection Agency (EPA) created in 1970 by US President Richard Nixon with the aim being to protect human health and the environment.[16] This was followed by other actions such as the Clean Air Amendments in 1970 and the Federal Water Pollution Control Amendments in 1972, the Safe Drinking Water Act of 1974, and the Resource Conservation and Recovery Act [RCRA] in 1976, to prevent and the control adverse effects due to improper disposal of solids and hazardous waste. In 1980, the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) was passed to act on the issue of hazardous waste material disposal sites in order to create a process for their remediation.

Until the formation of the President's Council on Sustainable Development (PCSD) in 1993 by President Clinton's administration, the emphasis was on saving the environment. Created through Clinton's executive order, PCSD put forth a report on 'Sustainable America' which stated that spoke about "a new consensus for Prosperity, Opportunity and a Healthy Environment for the Future'. It was an attempt to create a coordinated effort at a national level towards the goal of sustainable development. It

[14] (Carson 1962)

[15] (NEPA, The National Environmental Policy Act of 1969, as amended 1969), Sec. 101 [42 USC § 4331] (b) 1.

[16] (Agency, Committee on Incorporating Sustainability in the U.S. Environmental Protection 2011), 19.

also put more emphasis on the aspect of economic prosperity in sustainable development. The Council was terminated by an executive order 6 years later.

The conservation and preservation movements in the US progressed much in tandem, a case in point being the passage of the National Historic Preservation Act (NHPA) in 1966.

1.4. CONCLUSION

We have seen many definitions of 'Sustainability' in this chapter from organizations spanning the world. They might have different ways of approaches, some with an emphasis on environmental protection, others talking about the economics of sustainability, but they all converge on the idea that in order for future generations to avail of the limited natural resources of this planet, some proactive steps are necessary. Although the problem is a complex one, there have been efforts to propose solutions in ways that facilitate the application of the principles in varied contexts. One such concept is the 3Rs (Reduce, Reuse, and Recycle). The concept of Reduce, Reuse and Recycle, when used in the context of the building industry could be most aptly connected with Historic Preservation. Preserving an existing building leads to reduction in the use of resources that would have been needed to construct anew. Adaptive reuse of Historic structures, by definition, promote the principal of reuse existing products. In case of salvaged material reuse from those buildings that cannot be fully reused, the principle of Recycle is applied. Historic Preservation of existing buildings is, thus, a great example of the real world application of the idea of Sustainability.

CHAPTER 2: QUANTIFYING SUSTAINABILITY

2.1. INTRODUCTION

"If you cannot measure it, you cannot improve it"

Sir William Thomson, Baron Kelvin of Largs, proponent of absolute temperatures

It is important to measure change in conditions over time to determine the success or failure of actions. The net change could be positive, negative or null. In the realm of sustainability, the quantification of the processes is a much debated topic with discussions about the criteria that are included or excluded, acceptable upper and lower limits for the inputs and/or outputs, selecting the outputs that are to be measured and then, ideally controlled, etc.

A study of the various parameters used in the quantification process, especially in the field of resource utilization will help us better understand the final application of this knowledge. For example, the Green-Building Rating Systems that we will be studying in Chapter Three are based, to a large extent, on the sustainability indicators discussed in this chapter.

2.2. QUANTIFICATION

When we discuss quantification, we should not ignore the qualitative aspects of both Historic Preservation and Sustainable Design. At a very basic level, it can be measured by the human satisfaction at having preserved something of value for the future generations. The levels of this satisfaction differ according to the values of the society. On some level, it could also reflect how informed the property owners, users or developers are and having more dialogue with these stakeholders might be of help. But for this paper, the main focus will be on one specific kind of quantitative measurement, namely Green-Building Rating Systems.

The different systems that are in use at the moment to quantify overall environmental impacts, and not just buildings, use certain parameters or indicators that are measured, analyzed and then

controlled as desired and as possible. First we will take a look at some of the Sustainability Indicators and then look at some of these Quantification Systems.

2.3. PARAMETERS FOR QUANTIFYING SUSTAINABILITY

To make any kind of progress, it is important to understand and evaluate the existing situation, then formulate goals for the future, and then devise ways to achieve them. Measuring the various parameters and indicators gives us a framework for the action plans. There are various methods used to quantify sustainability using different indicators, indexes and benchmarks, such as the Triple Bottom Line accounting system used by corporations as well as the Environmental Sustainability Index and the Environmental Performance Index used by many countries. Benchmarks are a tool used to measure if the actions taken have created change for the positive or for the negative. An example of a benchmark is the level of the greenhouse gas emissions of 1990s. This was considered as the benchmark to promote the reduction in these emissions to those lower in later years. In other words, a benchmark is a point of reference to measure progress. A sustainability index uses data from various sources to inform about the chosen indicator. For example, the Environmental Performance Index will compare the effectiveness of the sustainable measures employed by different organizations by combining information from different environmental assessment criteria. Another one is the Happy Planet Index that measures human as well as environmental well-being. This index uses metrics such as life expectancy at birth and ecological footprint. Interestingly, in the 2012 Happy Planet Index, Costa Rica tops the list, with India in 34th place, France in the middle of the list at 50 and the United States at a dismal 114th place[17].

[17] (The new economics foundation n.d.), 1.

2.4. SUSTAINABILITY INDICATORS

2.4.1. DEFINITION

The OECD (Organisation for Economic Co-operation and Development) defines indicators as "A summary measure that provides information on the state of, or change in, a system" (OECD 2011b). Basically indicators are what we measure to assess if the goals that we aim for have been achieved or the extent to which they have been reached. The metric of this measurement is the unit by which the indicator is assessed. Indicators are measured to assess if the benchmark has been achieved.

To improve the processes that are involved in development and to formulate a plan of action, we need to decide on the indicators that might be important in the discussion on sustainable development.

Let us take the example of the indicators set by the European Union for their Sustainable Development Strategy. There are more than a 100 indicators[18] in the 2009 Monitoring Report of the European Union on Sustainable Development (APPENDIX B) but we will take into account selected indicators for our purpose since some, such as, Freshwater Resources might not be applicable to the topic of this study regarding Historic Preservation and others, although would have an effect but a distant one and not suitable for the scope of this study, such as the Globalization of Trade.

There are many different areas of focus that generate indicators to measure sustainability and these have been seen to guide the Green-Building Rating Systems as we will see in the next Chapter. Some of them are Energy Usage, Resources Management, Transportation systems, Waste Management and so on.

[18] (European Commission 2009), 8.

2.4.2. AN OVERVIEW OF SELECTED SUSTAINABLE DEVELOPMENT INDICATORS[19]

The Sustainable Development Indicators described below were selected keeping in mind the focus of this discussion, reflecting those parameters that might affect or be affected by building construction and rehabilitation or Historic Preservation criteria.

2.4.2.1. SUSTAINABLE CONSUMPTION AND PRODUCTION (SCP)

One of the areas of focus is the promotion of Sustainable Consumption and Production. Generally economic growth is equated with an increase in consumption as well as production and the two are often considered as principal driving forces of the economic development engine. Economic growth in a society leads to an improvement in the living standards for many people and, as such, is an evidently desirable outcome. However, an unrestrained increase in consumption, often a by-product of improved living standards, coupled with the depletion of the limited natural resources could lead to an alarming and, quite possibly, irreversible decline in future living conditions.

Furthermore, there are certain consumption and production methods employed today that have been known to lead to environmental degradation and could contribute towards increased pollution and global warming. The great rise in the human population, too, contributes to the overtaxing of the finite natural resources available to us. There is a need to change the patterns of consumption and production in a society that create these undesirable ill-effects.

The topic of Sustainable Development was discussed at length at the 2002 World Summit on Sustainable Development organized in Johannesburg where the 'Johannesburg Plan of Implementation'[20] stated,

[19] (European Commission 2009), 291.
[20] (United Nations 2002), 1.

> Governments, relevant international organizations, the private sector and all major groups should play an active role in changing unsustainable consumption and production patterns.

The impacts of unsustainable consumption patterns of the developed world affect the entire world. The energy needs of developed countries exceed the natural resources that they hold leading to transport of fuel all around the world. Additionally, globalization of the manufacturing processes, that is to say, shifting of the production assemblies to the less-developed countries for the cheaper labor and overheads leads to an increase in the freight transport needs. This, in turn, depletes the natural fuel reserves and at same time increases emissions of greenhouse gases due to the growing traffic movement.

One of the important objectives of the 2006 EU Sustainable Development Strategy (EU SDS) was to try to break the link between economic growth and environmental degradation. In other words, it had become necessary to take steps that would stop promoting economic growth at the cost of degrading the environment. The trade-off mentality had to be changed and thus a paradigm shift was called for. It involved strategies such as creating public awareness by involving citizens, corporations as well as social organizations to take responsibility for their consumption and production choices, improving the available products and processes by innovations and environmental technologies to reflect the new environmental standards, stimulate their usage and promoting green public procurement in the EU (many of these strategies are reflected in the Green-Building Rating Systems discussed ahead). Moreover, improved efficiency for resource usage as well as waste management were also points of interest. The UNEP, in conjunction with the European Commission conducts Sustainable Consumption and Production round tables to promote the system internationally, especially in emerging economies.

The following indicators are some of the subthemes for SCP.

2.4.2.1.A. RESOURCE PRODUCTIVITY AND DOMESTIC MATERIAL CONSUMPTION

One of the main objectives put forth in the EU Sustainable Development Strategy was the decoupling of economic growth and its sustainability goals. The sustainability indicator 'Resource Productivity' provides insight into the progress of this objective. Resource Productivity is the measure of the Gross Domestic Product (GDP) in relation to the Domestic Material Consumption (DMC). GDP is a measure of the economic activity whereas DMC measures the total quantity of materials used directly by the economy.

The 2009 Monitoring Report of EU defines Domestic Material Consumption as "the annual quantity of raw materials extracted from the domestic territory of an economy, plus all physical imports minus all physical exports". DMC can also be an indicator of the waste potential of the region as this consumption leads ultimately to the creation of waste.

According to the European Commission, resource productivity (the inverse ratio of the growth in GDP and the Domestic Material Consumption) in Europe increased by around 2.1% [21] between 2000 and 2005[22], signaling a possible decoupling between the two indicators.

2.4.2.1.B. MUNICIPAL WASTE GENERATED AND MUNICIPAL WASTE TREATMENT

The waste generated by a society is counted as a loss of resources and the ways to salvage some of this loss is to reduce, recycle and reuse (3R's) as much of the waste material as possible. Change in the consumption patterns is one of the solutions to this problem. The choices we make as consumers can lead to a reduction in the resultant waste produced. Waste material can be better dealt with by improving ways of collecting and sorting as well as improving the technology used for recycling and reuse. Public education as well as better choices by corporations and governments are important factors to effect this change.

[21] (European Commission 2009), 124.

[22] Although this increase in resource productivity was mainly due to overall rise in the GDP rather than the reduction in the DMC. (European Commission 2009), 45.

The EU policy rates waste prevention as the best practice followed respectively by recovery (which includes reuse, recycling, composting and incineration that also generates energy), incineration without energy generation and lastly, landfill, which is considered as the least environmentally friendly solution. The concept of life-cycle thinking is promoted in the EU sustainable development strategy.

2.4.2.1.C. ELECTRICITY CONSUMPTION OF HOUSEHOLDS AND FINAL ENERGY CONSUMPTION BY SECTOR

Unsustainable energy use trends create an enormous burden on the natural resources of the earth as well give rise to pollutants through emission of greenhouse gases due to the use of certain energy producing technologies. Moreover, energy production systems such as large hydroelectric dams create an imbalance in the natural ecosystems as well as displace large number of people. The measurement of the electricity consumption of households involves electricity used for all electrical appliances as well as that used for heating or cooling of interior spaces and water.

As per the EU report, there was an increase in the demand for electricity in Europe during the period from 1990 to 2006, with most of the demand arising from additions of new appliances, most notably air conditioning units.

Involving the public in analyzing and changing their energy consumption patterns is one of the ways of affecting lasting change. Final Energy Consumption by sector is the total energy use broken down into the various sectors such as households, industry, transport, services, agriculture etc.

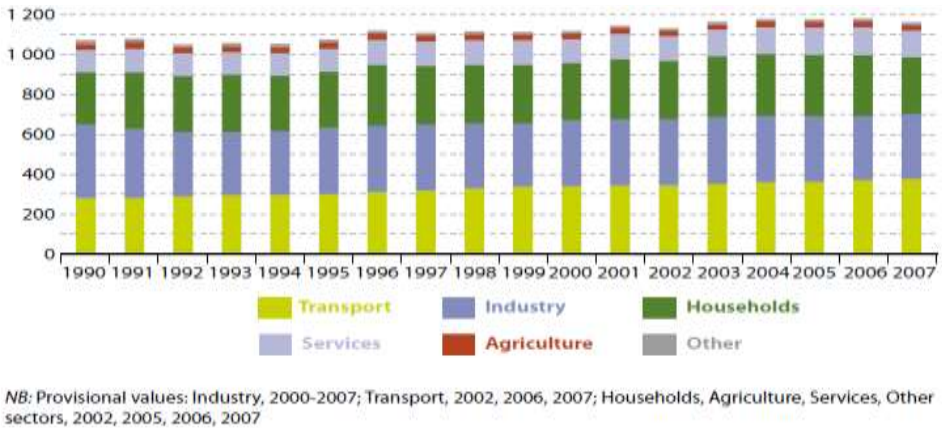

Figure 1. Final energy consumption, by sector, EU-27 (million tonnes of oil equivalent), Source: Eurostat (tsdpc320)

2.4.2.2. CLIMATE CHANGE AND ENERGY

Some of the sub-indicators are discussed below.

2.4.2.2.A. GREENHOUSE GAS EMISSIONS AND GREENHOUSE GAS EMISSIONS BY SECTOR

Greenhouse gases are gases that absorb the infrared radiation from the solar heating of the earth, trapping the escaping heat and leading to the phenomenon known as global warming. Some examples are carbon dioxide, methane and hydro fluorocarbons. The two highest greenhouse gas emission sources in Europe are the energy production (40%) and the transport sectors (24%).[23] As per the US EPA[24] the total emissions in the United States for the year 2012 were 6,526 million metric tons of CO_2 equivalent with the following percentages for the various gases: Carbon dioxide 82.5%, Methane 8.7%, Nitrous oxide 6.3% and Fluorinated gases 2.5%.

[23] (European Commission 2009), 79.
[24] (U.S. Environmental Protection Agency 2014), 1.

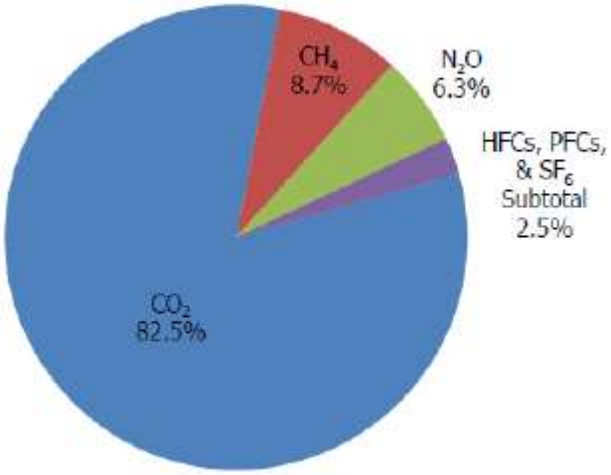

Figure 2. 2012 Greenhouse Gas Emissions by Gas (Percentages based on Tg CO_2 Eq.) (U.S. Environmental Protection Agency 2014)

Carbon dioxide (CO_2) has been named as the biggest contributor to the global warming. Also all the greenhouse gases are measured in the unit 'CO_2 equivalent', a unit developed by the Intergovernmental Panel on Climate Change (IPCC) in order to be able to compare the potential effects of different gases on the global warming. The concept of Global Warming Potential (GWP) defines the GWP of a greenhouse gas as "the ratio of the time-integrated radiative forcing from the instantaneous release of 1 kilogram (kg) of a trace substance relative to that of 1 kg of a reference gas[25]", which in this case was carbon dioxide (CO_2). Thus the weighted emissions for all the other gases are measured in million metric tonnes (teragrams) of CO_2 equivalent (Tg CO_2) and are calculated by multiplying the gas' emissions with the GWP which has been calculated considering the fact that different gases contribute at different rates to global warming.

[25] (Houghton , et al. 2001) 1.

Gas	GWP
CO_2	1
CH_4[a]	21
N_2O	310
HFC-23	11,700
HFC-32	650
HFC-125	2,800
HFC-134a	1,300
HFC-143a	3,800
HFC-152a	140
HFC-227ea	2,900
HFC-236fa	6,300
HFC-4310mee	1,300
CF_4	6,500
C_2F_6	9,200
C_4F_{10}	7,000
C_6F_{14}	7,400

Figure 3. Global Warming Potentials (100-Year Time Horizon) (U.S. Environmental Protection Agency 2014)

In 1998, members of the United Nations agreed to work towards reducing greenhouse gas emissions in a protocol signed at Kyoto, Japan.

Analyzing the sustainability indicator of 'Greenhouse gas emissions by sector' gives us information about the trends of greenhouse gas emissions from the different sectors of the economy and allows us to take the targeted actions to improve the situation. It also helps in measuring, more precisely, the effectiveness of the measures over time.

2.4.2.2.B. GREENHOUSE GAS INTENSITY OF ENERGY CONSUMPTION

Energy produced by using different fossil fuels have different effects on the environment. Some fossil fuels have a higher carbon-content, such as lignite and coal whereas natural-gas is a relatively low-carbon fuel. Thus using a lower-carbon fossil fuel for similar energy outputs would produce less greenhouse gas emissions and thus is preferred course of action. The indicator 'Greenhouse gas intensity of energy consumption' calculates the ratio between the greenhouse gas emissions related to energy production and the gross inland energy consumption, which is the total energy consumed within the borders of a country.

2.4.2.2.C. CONSUMPTION OF RENEWABLES AND ELECTRICITY GENERATION FROM *RENEWABLES*

Increased use of renewable sources of energy are a way to reduce the world's dependence on energy produced from non-renewable natural resources. The use of solar and wind power for energy generation are some examples of a renewable source of energy. Renewable energy sources contribute negligible to zero amount to the greenhouse gas tally.[26] This indicator is measured as the share of electricity produced by using renewable sources in the gross national electricity consumption. An indicative framework was established to increase the share of renewables in gross electricity consumption in the EU-27 to 21% by the year 2010.[27] As per March 2014 Eurostat statistics, the primary production of renewable energy within the EU-28 in 2012 was a 22.3 % share of total primary energy production.

2.4.2.2.D. COMBINED HEAT AND POWER (CHP)

Also known as Cogeneration, combined heat and power generation denotes simultaneous production of electricity and heat from a single fuel source.[28] The advantages of using a CHP system are less fuel requirement to produce each unit of energy which in turn reduces greenhouse gas emissions and pollution, and when used on-site eliminates transmission and distribution losses. Some CHP systems are gas turbine or reciprocating engine CHP systems and Steam turbine-based CHP systems. The scale of CHP plants can range from industrial size to those employed in single-family homes. The heat generated can be used in-house for space heating or can be distributed through district heating networks.

[26] (European Commission 2009), 85.
[27] (European Commission 2009). 85.
[28] (US EPA 2015) 1.

2.4.2.3. TRANSPORT IMPACTS

Transportation demand has been connected with economic growth with an increase in the GDP levels corresponding to increase in freight transport volumes. The total greenhouse gas emissions from transport for the EU-27 increased by 26 % between 1990 and 2007.[29]

There have been an improvement in the transport vehicle engine technology that are more fuel efficient and produce lesser greenhouse gas emissions, but the total CO_2 emissions remain above the targets. The creation of infrastructure for transport such as new roads affect the biodiversity of a region which is also affected by the pollution of the resultant increase in transport.

One of the measures proposed by the 2009 Monitoring Report of EU on Sustainable Development is "decoupling economic growth and the demand for transport with the aim of reducing environmental impacts".[30] Using locally produced materials is one way this can be promoted. Another measure is to encourage sustainable modes of transport such as use of public transport.

2.4.2.3.A. ENERGY CONSUMPTION OF TRANSPORT RELATIVE TO GDP AND VOLUME OF FREIGHT TRNASPORT RELATIVE TO GDP

The indicator 'Energy consumption of transport relative to GDP' is defined as the ratio between the energy consumption of transport and GDP. The next indicator, 'Volume of freight transport relative to GDP' is defined as the ratio between the volume of inland freight transport and the GDP and includes road, rail and inland waterways. Both indicator measures are used to better understand the dynamics between demand for transport and economic growth in order to define more effective steps to decouple the two.

[29] (European Commission 2009), 94.
[30] (European Commission 2009), 96.Box 3.1.

2.4.2.3.B. GREENHOUSE GAS EMISSIONS FROM TRANSPORT

As we have seen, the energy used for transportation is the second highest and consequently the greenhouse gas emissions too are very high. This is the only major category measured by the EU in their report that showed a substantial increase in the levels of greenhouse gas emissions form 1990. Their share grew from 14 % of total EU-27 emissions in 1990 to 19.5 % in 2007.[31] In March 2007, the EU made the commitment to reduce the greenhouse gas emissions by 20% by the year 2020.[32]

2.4.2.4. LAND USE

Land is another resource that is finite[33], especially arable land. There is also the matter of fragile ecosystems that are composed of land, water, and air that support a complex system of inter-connected flora and fauna. Development expansion resulting in the erection of industry such as manufacturing and power plants, spread of the urban infrastructure of buildings and roads as well as unsustainable exploitation of arable land deplete the land stock available for growing food for the ever-growing world population. The land use for urban development and infrastructure building is oftentimes an irreversible process and could aid in creating brownfields. The US EPA defines brownfields[34] as,

> "…real property, the expansion, redevelopment, or reuse of which may be complicated by the presence or potential presence of a hazardous substance, pollutant, or contaminant. "

2.4.2.4.A. CHANGE IN LAND COVER

The conversion of land-use to urban development and infrastructure purposes is the sustainability indicator that is measured to better understand the development process and to avoid overexploitation of

[31] (European Commission 2009), 111.

[32] (Commission of the European Communities 2008), 4.

[33] There have been many instances of reclaimed land projects such as a large part of the Belfast Harbor, the Fens in Eastern England in Europe, the Battery Park City in New York in the Us and also at many places around the world such as Palm Islands off Dubai and the East Coast Park in Singapore, where land is created by infilling a waterbody or by draining and dredging it at times.

[34] (U.S. EPA 2015) 1.

natural resources. According to Eurostat[35], the total built-up area[36] in France increased from 7,278 square kilometers in 2009 to 9,028 square kilometers by 2012.

To add to these uses, the increased generation of waste due to augmented as well as wasteful consumption patterns, such as non-recycled packaging material and building demolition material create the need for land-fills that render more land unusable for agriculture, thus overburdening the already overtaxed global food production systems.

Brownfield properties can be salvaged with some investment in the clean-up of hazardous material and reuse of the land which can contribute towards reducing blight and protect further environmental degradation by saving greenspaces and agricultural land from development.[37]

2.5. CONCLUSION

The choices of these indicators and their metrics as well as the goals set by the various organizations involved can be complex. The involvement of various governments who have to try to maintain the economic growth engine at the same time as fostering an environment of sustainable consumption and production strategies while trying to balance the uneven economic situations of different nations can seem to be counterintuitive processes. Then there is the corporate world driven by the goal of profit-making and not by altruistic motives of saving the earth. At the level of individuals who would have the smallest impact on the challenge of fighting environmental degradation, there is the perception of hopelessness in the entire process.

One of the ways to counter these seeming contradictions has been to formulate systems to quantify sustainable actions and to create legible, structured and scalable systems that will help in the formulation of actionable strategies, such as the 3R system that gives an easily understandable system for

[35] (Eurostat n.d.), 1.

[36] In the Eurostat report data, the total built-up area only includes land used for buildings and greenhouses and not roads and other uses. (Eurostat n.d.), 2.

[37] (U.S. EPA 2015), 1.

resource management. It can be used at micro as well as macro levels from a single household to a countrywide application.

Another application of the concept of sustainability, is the introduction of Green-Building Rating Systems that attempt to mitigate the harmful effects of the construction industry and encourage better use of available resources. The sustainability indicators discussed in this chapter such as transportation impact on the environment and land use patterns, etc. find a reflection in the measures proposed by many Green-Building Rating Systems, as discussed in detail in the next chapter.

CHAPTER THREE: GREEN-BUILDING RATING SYSTEMS

3.1. INTRODUCTION

The need for quantification of the environmental impact of the building industry has led to the advent of numerous green-building rating systems that offer the building industry tools to evaluate and assess the sustainability quotients of the projects. These green-building rating systems measure the environmental performances of the various aspects of the building's life -cycle. The set of parameters chosen for this purpose are related to the design, construction and operation of the structure with a certain number of points assigned for fulfilling the pre-decided performance benchmarks and goals. The aim of this process is to make these goals as quantifiable as possible. The total of these individual scores gives the final 'Green' rating for the project. There are, sometimes, systems of counterchecks and balances in place such as employment of independent third-party evaluators. Most such green-building rating systems are usually voluntary but more and more governments are mandating sustainable practices for their local building industries. A case in point would be the 2009 Executive Order 13514 by the American President that promoted the establishment of an integrated strategy towards sustainability in the Federal Government policy. The new policy encourages a shift towards designing, constructing, maintaining and, operating 'high performance sustainable buildings in sustainable locations.'[38]

Many local regulatory authorities have made new laws to promote green-building certifications. In the US, the General Services Administration (GSA) in 2010 upgraded its requirement for new construction to achieve LEED Gold certification.[39] Some states and cities also offer financial incentives for LEED certification.[40] Washington D. C. and Oakland now require that all municipal buildings be retrofitted to LEED Silver certification.[41]

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[38] (Executive Order 13514; Federal Leadership in Environmental, Energy, and Economic Performance 2009), 1.

[39] (U.S. General Services Administration 2010), 1.

[40] (Barbara A. Campagna 2008), 1.

[41] (Department of Consumer and Regulatory Affairs, District of Columbia n.d.), 1.

Some of the green-building rating systems in use are LEED, Green Globes, BREEAM, HQE, GRIHA, SKA etc. We will take a brief look at some of these systems in the next section.

3.2. AN OVERVIEW OF SOME GREEN-BUILDING RATING SYSTEMS

3.2.1. LEED (LEADERSHIP IN ENERGY AND ENVIRONMENTAL DESIGN)

3.2.1.1. BACKGROUND

The U. S. Green Building Council was established in 1993 (USGBC) with the mission "…to transform the way buildings and communities are designed, built and operated, enabling an environmentally and socially responsible, healthy, and prosperous environment that improves the quality of life."[42] The Green Building Council was a result of the collaboration between a real-estate developer, David Gottfried and a scientist, Rob Watson. In the words of the CEO Rick Fedrizzi, "If we could invite business to the table, we could develop standards relative to building performance, buy in at the very top, and be able to transform the marketplace toward sustainable buildings."[43] The 'Leadership in Energy and Environmental Design (LEED) green-building rating system™ that started in this fashion, developed further to create tools and performance criteria to encourage the adoption of sustainable building practices.[44] By 1998, the pilot program titled LEED 1.0 (LEED - New Construction NCv1.0) was released. In the next two pilot period years, extensive revisions were done and LEED NCv2.0 was released in March 2000 which was upgraded to LEED NCv2.1 in 2003.[45] The next version appeared in 2005, the LEED NCv2.2. In 2009, LEED 2009 (also named previously as LEED v3) was released with some revisions in 2011. The latest version the LEEDv4 was released in November 2013 and will be mandatory from October 2016.[46] Until then projects can apply for the LEED 2009 certification.

[42] (U.S. Green Building Council (USGBC) n.d.), 1.
[43] **Invalid source specified.**, 1.
[44] (Barbara A. Campagna 2008), 1.
[45] (Buddenborg 2006), 67.
[46] (Roberts, LEED 2009 Registration Extended to October 2016 2014),1.

3.2.1.2. LEED RATING SYSTEMS

We will take a look at the LEEDv4 system. The LEED roster consists of five rating systems which, in turn, are applicable to various types of projects. The rating systems are Building Design + Construction, Interior Design + Construction, Building Operations + Maintenance, Neighborhood Development, and Homes. The individual rating systems adjust the requirements according to the project types to which they are applicable. [47]

BUILDING DESIGN + CONSTRUCTION(BD+C)

Used for buildings under construction or those undergoing major renovations. The project types include New Construction, Core & Shell, Schools, Retail, Hospitality, Data Centers, Warehouses & Distribution Centers and Healthcare.

INTERIOR DESIGN + CONSTRUCTION(ID+C)

Used for projects where a total interior fit-out is undertaken. The project types include Commercial Interiors, Retail and Hospitality.

BUILDING OPERATIONS + MAINTENANCE (O+M)

Used for existing buildings undergoing improvement work but with little or no construction. The project types include Existing Buildings, Schools, Retail, Hospitality, Data Centers and Warehouse & Distribution Centers.

NEIGHBORHOOD DEVELOPMENT (ND)

This rating system is used for neighborhood development projects that consist of multiple uses such as residential, nonresidential or mixed-use. The projects can apply at any stage, from concept design to construction.

[47] (USGBC, LEED n.d.),1.

HOMES

Used for single family homes, low-rise multi-family (1-3 stories), or mid-rise multi-family (4-6 stories). The project types include Homes and Multifamily low-rise and multifamily mid-rise.

Each of these rating systems has a number of credits categories with points allotted to each of the categories. There are some 'prerequisite' categories that do not have any points allotted but need to be fulfilled to get a certification.

Points are awarded for various types of efficiency and design actions which are divided into various credit categories.

The Credit Categories for LEED v4[48] are as follows:

Integrative Process

Location and transportation

Materials and Resources

Water Efficiency

Energy and Atmosphere

Sustainable Sites

Indoor Environmental Quality

Innovation

Regional Priority credits

[48] The Credit Categories for LEED v3 2009 were: Sustainable Sites, Water Efficiency, Energy & Atmosphere, Materials & Resources, Indoor Environmental Quality, Innovation & Design Process, and Regional Priority Credits

LEED ND (Neighborhood Development) has three additional categories: Smart location & linkage, Neighborhood pattern & design, and Green infrastructure & buildings.

Most categories have certain pre-requisite credits that are mandatory. From the rest of the available credits, the project team can choose those that are relevant to the project and that they can fulfill. There are also certain Minimum Program Requirements (MPR) which are non-negotiable e.g. the project must be at a permanent location and for LEED BD+C the project must be minimum 1000 square feet in gross floor area etc. [49] The total number of points achieved will determine the level of the LEED certification. There are four levels of certification, Certified, Silver, Gold and Platinum.

Table 1. LEED Certification levels Source: http://www. usgbc. org/leed

Levels of Certification	Points
Certified	40-49
Silver	50-59
Gold	60-79
Platinum	80+*

*Maximum points possible are 110.

3.2.1.3. FLEXIBILITY

The choice of credits gives a certain amount of flexibility to the project team.

INNOVATION & EXEMPLARY PERFORMANCE

Five points are awarded for Innovation in Design or Exemplary performance in the other credits.

[49] (USGBC, LEED v4 User Guide 2014)

3.2.1.4. CERTIFICATION PROCESS

The process of certification starts by making the choice of the rating system and registering the project online. Then the project team works on the documentation for all the pre-requisite credits as well as for the credits that they want to achieve. The documentation is uploaded and submitted for certification. There are two stages of reviews: preliminary and final. During the preliminary review, the project team receives technical advice on any additional work required for credit fulfillment. The final review leads to the final score and the appropriate certification. The team can accept of appeal the certification awarded at this point.

3.2.2. GREEN GLOBES

3.2.2.1. BACKGROUND

The Green Globes green-building rating system used in the United States as well as in Canada has been developed by the Green Building Initiative (GBI). The technical committees that worked on this rating system followed the ANSI standards.[50]

Inspired by BREEAM (UK), the GBI decided to adopt a Canadian, web-based and interactive learning tool to be used for commercial buildings in the United States. At the end of 2004, the Green Globes environmental assessment and rating tool was launched in the US market. In 2009, the GBI became and ANSI (American National Standards Institute) developer, the first to have the privilege. Using this process, it created the ANSI/GBI 01-2010: green-building assessment protocol for commercial buildings from its Green Globes rating system for New Construction. Updating of the system has been ongoing in 2014 and 2015.[51]

3.2.2.2. RATING SYSTEM

The Green Globes system has three assessment tools, New Buildings or Significant Renovation, Management and Operation of Existing Buildings and Sustainable Interiors.[52]

All the three tools use a weighted 1000-point scale. For certification for New Construction and Existing Buildings, a minimum overall score of 35% needs to be achieved. The certifications awarded are 1 to 4 Globes. The points scoring for Sustainable Interiors is explained further ahead in this section.

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[50] (AIA Sustainability Discussion Group May 2008), 3.
[51] (Green Building Initiative 2014)
[52] (GBI n.d.)

GREEN GLOBES FOR NEW CONSTRUCTION

The seven assessment areas for New Construction are Project Management, Site, Energy, Water, Materials and Resources, Emissions, and Indoor Environment. The following table gives the details for these assessment areas.

Table 2. Green Globes New Construction Certification Source: http://www.thegbi.org/green-globes-certification/how-to-certify/new-construction/

Environmental Assessment Area	Points	Description
Project Management	50	Integrated Design Process, Meetings, Performance Goals, Environmental Management, Commissioning
Site	115	Development Area, Ecological Impacts, Stormwater Management, Landscaping, Exterior Light Pollution
Energy	190	Performance, Demand, Metering, Measurement and Verification, Building Opaque Envelope, Lighting, HVAC Systems and Controls, Efficient Equipment, Renewable Energy, Energy Efficient Transportation
Water	110	Consumption, Cooling Towers, Boilers & Water Heaters, Water Intensive Applications, Treatment, Alternate Sources, Metering, Irrigation
Materials & Resources	125	Building Assembly, Interior Fit-outs, Re-use, Waste, Building Service Life Plan, Resource Conservation, Building Envelope
Emissions	50	Heating, Ozone-depleting Potential, Global Warming Potential
Indoor Environment	160	Ventilation, Source Control and Measurement, Lighting Design and Systems, Thermal Comfort, Acoustic Comfort
Total Points	1000	

GREEN GLOBES FOR EXISTING BUILDINGS

The six assessment areas for Existing Buildings are Energy, Water, Resources, Emissions, Indoor Environment, and Environmental Management. The following table gives the details for these assessment areas.

Table 3. Green Globes New Construction Certification Source: http://www.thegbi.org/green-globes-certification/how-to-certify/existing-buildings/

Environmental Assessment Areas	Points	Description
Energy	350	Performance, Efficiency, Management, CO2, Transportation
Water	80	Performance, Conservation, Treatment
Resources	110	Waste Reduction, Recycling
Emissions	175	Boilers, Water Effluents, Hazmat
Indoor Environment	185	Air Quality, Lighting, Noise
Environmental Management	100	EMS Documentation, Purchasing, Environmental Awareness
Total Points	1000	

GREEN GLOBES FOR SUSTAINABLE INTERIORS

The three key performance indicators that dictate the point scoring method for Sustainable Interiors are Energy Efficiency, Materials Choices and Resource Consumption and Indoor Environmental Quality. Projects have to achieve a minimum number of points in each of these three areas. Other environmental assessment areas included are Project Management, Water, and Emissions etc.

3.2.2.3. CERTIFICATION PROCESS:

The Green Building Initiative provides a two-part, third-party assessment for compliance with the rating system. The first part focuses on design evaluation at post construction-document phase. The second part is a walkthrough evaluation post actual construction. There is also a self-assessment option using an online questionnaire that does not need project registration.[53]

3.2.2.4. GUIDING PRINCIPLES COMPLIANCE (GPC) ASSESSMENT PROGRAM

Green Globes also has an innovative tool known as Guiding Principles Compliance (GPC) Assessment Program. It was designed specifically for the US federal agencies to comply with the Executive Order 13514[54] which aims to promote sustainable practices for the US Government. It was the first such third-party assessment and rating program and helps diverse government agencies by collating the various requirements of the Order. It is applicable only to New Construction and Exiting Buildings and has a 100 point scale and spans over five environmental assessment areas that fulfill the five Federal guiding Principles:

- To employ integrated assessment, operation, and management principles
- Optimize energy performance
- Protect and conserve water
- Enhance indoor environmental quality
- Reduce environmental impact of materials

[53] (AIA Sustainability Discussion Group May 2008), 3.

[54] "…Federal agencies shall increase energy efficiency; measure, report, and reduce their greenhouse gas emissions from direct and indirect activities; conserve and protect water resources through efficiency, reuse, and storm water management; eliminate waste, recycle, and prevent pollution; leverage agency acquisitions to foster markets for sustainable technologies and environmentally preferable materials, products, and services; design, construct, maintain, and operate high performance sustainable buildings in sustainable locations; strengthen the vitality and livability of the communities in which Federal facilities are located; and inform Federal employees about and involve them in the achievement of these goals." (Executive Order 13514; Federal Leadership in Environmental, Energy, and Economic Performance 2009), 1.

3.2.3. BREEAM

3.2.3.1. BACKGROUND

Building Research Establishment's Environmental Assessment Method (BREEAM) is a UK based sustainability rating scheme for the built environment. It was launched in 1990 and is now used in many countries.[55] As of 2015, BREEAM has been used to certify over 260,000 building assessments across the building life cycle and it is being applied in over 50 countries.

BREEAM, one of the earlier sustainability rating schemes for the built environment, has contributed much to the strong focus on sustainability in building design, construction and use in UK. BREEAM is now an international standard that is locally adapted, operated and applied through a network of international operators, assessors and industry professionals.

Through its application and use BREEAM helps clients measure and reduce the environmental impacts of their buildings and in doing so create higher value, lower risk assets.

3.2.3.2. RATING SYSTEM

BREEAM can be used for building types such as residential and commercial buildings, schools, healthcare buildings, offices, and industrial structures. BREEAM International has four schemes available: BREEAM International New Construction (NC), BREEAM International Refurbishment & Fit-Out, BREEAM In-Use International, and BREEAM Communities Bespoke International.

The BREEAM rating system awards points or 'credits' for actions taken in the areas of Energy (operational energy and carbon dioxide), Management (management policy, commissioning, site management and procurement), Health and Wellbeing (indoor and external issues such as noise, light, and air quality. Transport (transport-related Carbon Dioxide (CO_2) emissions and location related factors), Water consumption and efficiency, Materials (embodied impacts of building materials, including lifecycle impacts like embodied carbon dioxide), Waste (construction resource efficiency and operational waste

[55] (BRE Global Limited 2015), 5.

management and minimization), Pollution (external air and water pollution), Land Use (type of site and building footprint), and Ecology (ecological value, conservation and enhancement of the site).

The scores for each of these sections are calculated by multiplying the total number of credits received by an environmental weighting factor decided upon by the relative importance of that section as regards to its environmental impact. The total of all the section scores gives a final tally which then leads to the following rating:

Pass (30%)

Good (45%)

Very Good (55%)

Excellent (70%)

Outstanding (85%)

(Please see Appendix C for a sample ratings calculation.)

3.2.3.3. FLEXIBILITY

Minimum standards of performance have to be achieved in key areas such as energy, water and waste to be eligible for the different ratings. For example, one credit must be achieved in the category 'Responsible Construction Practices' for the project to even be eligible for an 'Excellent' rating. (More details about other compulsory credits can be found in Appendix D).

After fulfilling the minimum requirements, the rating system has a flexible approach and credits can be traded to achieve the target rating. Non-compliance in one area can be compensated through compliance in other areas.

Another aspect that promotes flexibility is the changes in weightings according to the location and the local climactic conditions. BREEAM uses the following climatic zones classification for its purposes.[56]

Equatorial – tropical climates with temperatures above 18°C,

Arid – dry climates (semi-arid and desert climates),

Warm temperate – mid-latitude climates (warm, dry summers with cool, wet winters),

Snow – temperate, temperatures usually between -3°C and 10°C (sub-arctic/temperate alpine areas and low precipitation),

Polar – permafrost/tundra climates.

For calculations for the credit 'Wat 01' (Water Consumption) three precipitation zones are considered:

Precipitation zone 1: corresponding to Köppen's precipitation regions[57] 'f' (fully humid) and 'm' (monsoonal)

Precipitation zone 2: corresponding to Köppen's precipitation regions 's' (summer dry) and 'w' (winter dry)

Precipitation zone 3: corresponding to Köppen's precipitation regions 'S' (steppe) and 'W' (desert)

(See Appendix E and Appendix F for a world maps of precipitation zones.)

[56] (BRE Global 2014), 16.

[57] Köppen Climate Classification System is widely used for the classification of different climates around the world. It proposes five major climate types based on annual as well as monthly data averages for temperature and precipitation. The system was first presented in 1884 by Russian German climatologist Wladimir Köppen.

3.2.3.4. INNOVATION

For every innovation, the assessor can apply to BRE Global for recognition of the new design or construction method, process or feature. Upon receiving this innovation credit, 1% can be added to the building's total score with a maximum limit of 10 such credits.

3.2.3.5. CERTIFICATION PROCESS:

The services of a licensed BREEAM assessor or a BREEAM In-Use Auditor (according to the project type) are required for the project assessment. The first step is to decide the type of Scheme that is suitable for the project. The assessor can then do a pre-assessment using the Pre-assessment Estimator which will give a general benchmark for the current status and can be used to prepare an action plan for achieving the desired score. After registering the project, the certification process will take place, whether for the Design stage (optional) or Post-construction (mandatory).

3.2.3.6. OTHER RATING SYSTEMS

BREEAM INTERNATIONAL NEW CONSTRUCTION (NC)

The New Construction scheme is used for sustainability assessment of a project at its design and construction stages. Apart from the mandatory ten BREEAM categories mentioned earlier, this scheme also includes minimum standards that must be met for compliance, exemplary level requirements and compulsory post-construction stage assessment.[58]

BREEAM INTERNATIONAL REFURBISHMENT & FIT-OUT

The Refurbishment and Fit-Out scheme is used exclusively for projects where there is extensive interior work done. The BREEAM International New Construction 2013 Technical Manual defines major refurbishment as, "construction that results in the fundamental remodeling or adaptation of existing elements of the building envelope, structure and renewal of key building services".[59]

[58] (BRE Global 2014), 1-20
[59] (BRE Global 2014), 368:APPENDIX C

The Manual further explains the term ‘elements’ as structural/building envelope elements as including walls (including glazing), roofs (including roof lights), floors and building services elements such as lighting (artificial and daylighting), heating, mechanical ventilation/cooling plant, ductwork, and water/drainage systems.

A new scheme launched on the 16th of June, 2015 is titled BREEAM International Refurbishment and Fit-out 2015 (BREEAM International RFO) and according to the BRREAM website[60], it will have a modular approach with four assessment parts, Building fabric and structure, Core services, Local services and Interior design.

BREEAM IN-USE INTERNATIONAL

This scheme is used chiefly to reduce the running costs of a building by improving its environmental performance. It is used for non-domestic buildings. It is comparable to the LEED Operations and Maintenance rating system.

BREEAM COMMUNITIES BESPOKE INTERNATIONAL

The Bespoke[61] schemes of BREEAM, in general, are helpful for buildings that do not fit in the other schemes and need to work with criteria adapted for their specific situations. The basic principles of BREEAM are followed while lending a flexible approach to the project’s assessment. The BREEAM Communities Bespoke International is a scheme for assessment of housing provisions, transport networks, community facilities and economic impacts of large-scale developments. It is comparable to the LEED Neighborhood Development rating system and aims to address the challenges of rapid urbanization and the resulting climate change.

[60] http://www.breeam.org/page.jsp?id=353
[61] Bespoke: made to the customer's specifications. (Collins 2015)

COUNTRY-SPECIFIC BREEAM SCHEMES

The BREEAM website states that, "…where the country has a NSO (National Scheme Operator) offering a country-specific local scheme that is appropriate to the building type, their scheme must be used in preference to BREEAM International."[62]

BRE Global collaborates with different countries to create their own sustainability assessment methods that are well suited to the local cultural, social and climatic conditions. The rating systems are in the local language with trained local assessors and also in tandem with the country specific building regulations. After a scheme has been developed, the BRE Global signs a Framework Agreement with the local National Scheme Operator (NSO). The NSO for the Netherlands (BREEAM NL) is the Dutch Green-building Council and in Spain (BREEAM ES) it is the Instituto Tecnológico de Galicia.[63]

3.2.3.7. FOCUS ON HISTORIC PRESERVATION

The BREEAM New Construction 2014 version that was being used for refurbishments and fit-out projects will be replaced by the newly launched BREEAM Non-Domestic Refurbishment 2014. One of the fundamental change is the option to choose the level of accreditation according to the project scope of work. The new assessment scheme has four modules to choose from: Part One – Building fabric and structure, Part Two - Core services, Part Three - Local services, and Part Four - Interior design.[64] This lends flexibility as it allows the client to apply for a certification that fits in with the scope of work on site. A Grade I heritage structure, where the Fabric and Structure module might not be feasible could attempt the certification for the other three modules, for example. Additionally, the new BREEAM International Refurbishment and Fit-out 2015 has two extra credits for Historic Structures in the category 'Ene 01 Reduction of energy use and carbon emissions'. They are awarded if a study carried out by a 'Suitably Qualified Heritage Conservation Specialist' can justify any alternative solutions for improving

[62] (Limited 2015). 1.
[63] (BRE Global Limited 2015), 5.
[64] (Twin and Earth Limited 2014), 1.

ventilation, air tightness and moisture control but with an emphasis on safeguarding the historic building fabric. The credits are also awarded if this study concludes that these improvements cannot be made due to conservation issues.[65] Features such as these could be helpful in customization of the BREEAM scheme for unique Historic Preservation projects.

There are also changes in the application methodology for the criteria. There is an exemption in this new scheme to allow use of specific paints or varnishes with high levels of VOCs when a local or national Authority or conservation body makes an explicit request.[66] On the other hand, exclusion of credits for criteria such as Site Selection, which would have rewarded credits for a project on a previously-used location would reduce the credit tally. Overall, though, the new scheme appears to be beneficial for Historic Structure evaluation.[67]

[65] (BREEAM 2015), 125.
[66] (McLoughlin 2015), 1.
[67] http://ska-tool.rics.org/projects/fernow-hall/design/assessment/

3.2.4. HQE

3.2.4.1. BACKGROUND

HQE certification is a French green-building rating system that is used worldwide. HQE stands for 'Haute Qualité Environnementale' translated as 'High Environmental Quality'. The Association HQE was established in France in 1996 and the HQE system with its 14 target areas was defined by 2002. In 2004, the Association HQE was converted to a public service organization according to French regulations. Cerway, created in 2013, is the international operator for the HQE certification.[68] The objectives of the certification focus mainly on the life cycle analyses of the building scale and also deals with the issues of health, personal comfort and indoor environment.[69]

The certification scheme is created by collaboration between the various parties involved in the project such as the owners, users, developers, and local authorities.[70] Additionally, there is a Project Management aspect to the certification that is able to provide quality control and assessments over the lifetime of the project.

3.2.4.2. RATING SYSTEM

The rating system focuses on areas of Energy, Environment, Health and Comfort of Use[71] which, in turn, have a total of 14 target areas.

[68] (Cerway 2013), 2.
[69] (Cerway, What is HQE? 2013), 1.
[70] (Cerway, HQE CERTIFICATION 2013), 1.
[71] (HQE-CERWAY 2015), 9.

Table 4. HQE Target Areas for Buildings Under Construction Certification[72]

Target1 – The building's relationship with its immediate environment
Target2 – Integrated choices of construction products, systems and processes
Target3 – Low environmental impact worksite
Target4 – Energy management
Target5 – Water management
Target6 – Operational waste management
Target7 – Maintenance and durability of environmental performance
Target8 – Hygrothermal comfort
Target9 – Acoustic comfort
Target10 – Visual comfort
Target11 – Olfactory comfort
Target12 – Health quality of spaces
Target 13 – Health quality of air
Target 14 – Health quality of water

The rating system offers three different certifications for domestic as well as international projects: Buildings under construction, Buildings in Operation and Sustainable Urban Development.

BUILDINGS UNDER CONSTRUCTION

This certification covers the environmental management of the entire project as well the environmental performance of the building. The Management scheme consists of the results of preliminary reviews and the resultant actions taken, the Environmental Building Performance assessments, corrective actions according to the assessments and records of non-achievement of any targets.[73]

[72] (HQE-Cerway 2014), 9-29.
[73] (HQE-Cerway 2014), 10.

NON-RESIDENTIAL BUILDINGS IN OPERATION

This certification deals with the operational aspects of one or more buildings. There are provisions in the contract to keep assessing the Sustainability Compliance of the project during the entire life cycle of the structure.

URBAN PLANNING AND DEVELOPMENT.

This certification deals with sustainable land development and also takes into account issue related to the control over various processes involved. It involves the management and assessment of the project as well the design and development processes.

The scores are presented in stars, from none to twelve, leading to five different rating levels awarded.

Table 5. HGE Rating System[74]

Overall Score	Rating
No Stars but achieved ALL Prerequisites	HQE PASS
1-4 Stars	HQE GOOD
5-8 Stars	HQE VERY GOOD
9-11Stars	HQE EXCELLENT
12 Stars	HQE EXCEPTIONAL*

3.2.4.3. CERTIFICATION PROCESS:

An application is made to Cerway by completing the application dossier and providing the required documents. Once the application is verified by Cerway a contract offer is sent to the applicant.

[74] (HQE-Cerway 2014), 7.

This offer contains the list of services that can be provided according to the application and the applicable fees. The certification process starts after this contract is signed.

The Buildings under Construction certification process has three stages. There is a Pre-project Audit, a Design Audit and an Execution Audit. If the application is made when the project is at an advanced stage, there is an option for group audits upon approval by Cerway.[75]

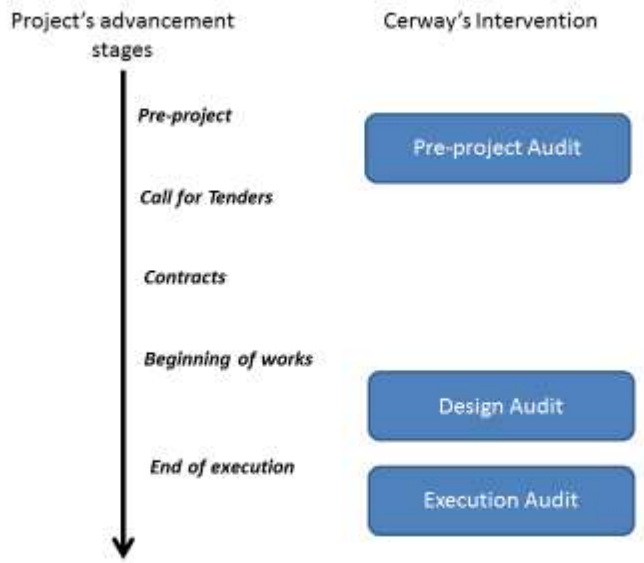

Figure 4. THE HQE™ CERTIFICATION PROCESS [76]

The Buildings in Operation Certification Process has three distinct certification areas that can be used together or separately. They are:

Sustainable Building

Sustainable Management

Sustainable Use

This certification is applicable to domestic and international, non-residential existing buildings. There is a certification cycle of five years duration during which successive interventions assess the

[75] (HQE-CERWAY 2015), 11.
[76] (HQE-CERWAY 2015), 11.

compliance of the project. The first phase of the certification is called the 'Initial Certification' after which the project has validity during the certification cycle of five years provided it stays in compliance. After the first five years, renewals of certification are possible, each lasting another five years. The Initial Certification cycle has two phases: One Admission intervention and four, annual Follow-up interventions. The Renewal Certification cycle also has two phases: One Renewal intervention and four, annual Follow-up interventions.

The Urban Planning and Development assessment has two main stages: an Admission intervention and the Final intervention. The Admission intervention consists of a Project Management System (PMS) audit and a certificate is issued afterwards. The Final intervention is an audit of the PMS within 6 months of the handover of communal spaces and the completion of 100% of the site construction. There is another stage, the Follow-up interventions, which are annual PMS audits required to maintain or update the Certificate.

3.2.4.4. FLEXIBILITY

There is a one-on-one dialogue between Cerway and the applicant that leads to project specific parameters and decisions. The applicant plays a vital role in deciding these parameters as long as the minimum requirements thresholds are achieved.[77] There are three audits in the entire process and after each audit, a report is sent to the applicant who then has the opportunity to comment on it. This makes the system more transparent and adaptable, providing an element of flexibility for different projects.

[77] (Cerway, HQE CERTIFICATION 2013)

3.2.5. SKA

3.2.5.1. BACKGROUND

SKA rating system is a sustainability rating system of the Royal Institute of Chartered Surveyors (RICS). It started out as a research project in 2005 by Skansen, a British fit-out and refurbishment contractor, which is how it got its name. In 2009, it was taken over by RICS. It used mainly for offices with a retail version currently in development.[78]

3.2.5.2. RATING SYSTEM

The system assists the clients in assessments of fit-outs and refurbishment projects by analyzing the project details for a set of good practice criteria also known as Good Practice Measures (GPM). There are more than a hundred such GPMs from which to choose and they span the areas of Waste, Water, Pollution, Energy and CO_2, Transport, Materials and Well-being.

A detailed list of the GPMs can be found in Appendix K

3.2.5.3. FLEXIBILITY

The best advantage of using SKA rating system is the flexibility that it offers. Each project is different in its own right and thus, using a weighty rating system might prove to be of high cost and low relevance.[79] While using SKA, the project is scored only on the chosen GPMs (called measures in scope) that are relevant to the scope of work (a minimum of 20[80]). Generally, from 30 to 60 measures are found to be applicable to most projects.[81] The GPMs are ranked from 1 to 104 (1=highest, 104=lowest) and a project is expected to achieve a number of the topmost ranking GPMs in its collection of the measures is scope. These are known as the 'gateway measures'.[82]

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[78] (RICS - Royal Institute of Chartered Surveyors 2014)
[79] (RICS - Royal Institution of Chartered Surveyors n.d.)
[80] (BSRIA Ltd 2011)
[81] (Designing Buildings Ltd. 2015)
[82] As an example, 12 out of the 15 gateway measures have to be achieved to get a Gold rating. (BSRIA Ltd 2011)

3.2.5.4. CERTIFICATION PROCESS:

There is a free online SKA rating tool that can be used by the clients but there is a fee to receive professional certification. RICS charges £60 for each certification. Additionally there are the fees of the assessors that vary from £2000-£3000 according to the project.[83]

The certification process has three stages. The first one is the design phase where the GPMs are identified, the second one is called the Handover, where documentation and evidence is gathered from the Operations and Maintenance (O&M) manuals. The third and final one is called Occupancy, which is optional and measures the actual performance of the fit-out after a year of use. The certification can be obtained after the second stage, the Handover.

Table 6. SKA Scoring table

Percentage of measures achieved	Rating
75%	Gold
50%	Silver
25%	Bronze

3.2.5.5. FOCUS ON HISTORIC PRESERVATION

Since the rating system is designed mainly for fit-outs of existing spaces and has an inherently flexible structure in its application, it could be very amenable for rehabilitation projects in historic structures undergoing an interior rehab without new construction. Although, at present, there is a limitation as the scheme is applicable only to offices or retail projects, which could exclude some preservation and adaptive reuse projects.

[83] (Designing Buildings Ltd. 2015)

3.2.6. GRIHA

3.2.6.1. BACKGROUND

Green Rating for Integrated Habitat Assessment (GRIHA) is an Indian Green-building Rating system developed by the GRIHA Council founded by TERI (The Energy and Resources Institute, New Delhi) in conjunction with MNRE (Ministry of New and Renewable Energy of the Government of India) in 2005.[84] It was adopted as the national green-building rating system by the Government of India in 2007.[85]

3.2.6.2. RATING SYSTEM

The GRIHA rating system has, in total, 34 different criteria spread over various sections such as Site selection and site planning, Conservation and efficient utilization of resources, Building operation and maintenance, and Innovation. Eight of the 34 criteria are compulsory, four partly mandatory and the rest are optional and award specific points on completion. The maximum achievable points are 100 and the total number achieved leads to the appropriate level of certification.[86]

The various criteria are chosen for the tropical Indian climate and have a focus on non-air conditioned or partially air-conditioned structures, which form the bulk of the existing Indian building stock.[87] For a complete list of the various Criteria, please see Appendix I.

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[84] http://www.grihaindia.org/index.php?option=com_content&view=article&id=73&t=Green_Rating_for_Integrated_Habitat_Assessment, 1.

[85] Ibid.

[86] http://www.grihaindia.org/index.php?option=com_content&view=article&id=87

[87] (Ministry of New and Renewable Energy, Government of India and The Energy and Resources Institute 2010), 17.

Table 7. GRIHA rating system[88]

Points achieved	GRIHA Rating
50-60	One star
61-70	Two stars
71-80	Three stars
81-90	Four stars
91-100	Five stars

SVAGRIHA

Small Versatile Affordable GRIHA (SVAGRIHA) is a rating system for smaller buildings with a built-up area of under 2500 square meters. It is used for assessment of single family residences, small offices, schools, motels, and commercial buildings.[89] The maximum number of possible points is 50.

Table 8. SVAGRIHA Scoring table[90]

Points achieved	SVAGRIHA Rating
25-29	One star
30-34	Two stars
35-39	Three stars
40-44	Four stars
45-50	Five stars

[88] (Ministry of New and Renewable Energy, Government of India and The Energy and Resources Institute 2010), 42.

[89] Factory buildings less than2500 sq. m. are not eligible for SVAGRIHA rating.

[90] (The Energy and Resources Institute, and Association for Development and Research of Sustainable Habitats 2011), 12.

Table 9. SVAGRIHA criterion points distribution[91]

Criterion number	Criterion name	Points
1	Reduce exposed, hard paved surface on site and maintain native vegetation cover on site	6
2	Passive architectural design and systems	4
3	Good fenestration design for reducing direct heat gain and glare while maximizing daylight penetration	6
4	Efficient artificial lighting system	2
5	Thermal efficiency of building envelope	2
6	Use of energy efficient appliances	3
7	Use of renewable energy on site	4
8	Reduction in building and landscape water demand	5
9	Rainwater harvesting	4
10	Generate resource from waste	2
11	Reduce embodied energy of building	4
12	Use of low-energy materials in interiors	4
13	Adoption of green lifestyle	4
14	Innovation	2
	Total	50

[91] (The Energy and Resources Institute, and Association for Development and Research of Sustainable Habitats 2011), 11.

These 14 criteria are divided into 5 sub-groups, Architecture and Energy, Water and Waste, Materials, Landscape, and Lifestyle. In order to receive any rating, a certain number of points need to be achieved in each sub-group.[92]

GRIHA LD (LARGE DEVELOPMENT)[93]

This rating system was developed to assess the sustainability performance of the rapid urbanization taking place in most Indian towns and cities. The projects eligible for this system are large (mixed–use) townships (housing complexes by builders, urban development organizations, housing board and public sector undertaking townships. Also eligible are educational and institutional campuses, medical colleges and hospital complexes, special economic zones, and large hotels/ resorts. The six areas under assessment are site planning, energy, water and waste water, solid waste management, transport and social. Each of these sections is evaluated on two parameters, Quantitative and Qualitative (except for the social section which only uses Qualitative parameters) and their net impacts are used to calculate the overall impact as shown below.

[92] Details in Appendix J
[93] (Griha Council 2015), 1.

Table 10. GRIHA LD - Final Design Impact - Quantitative[94]

Final Design Impact - Quantitative			
Section	Quantitative Impact (from 0 to 100%) (Q_n)	Normalizing multiplier (M)	Final impact score in each section (I_n)
Site Planning	0-100	0. 9	Σ ($I_n = Q_n$ X M) [95]
Energy	0-100	1. 0	
Water	0-100	1. 0	
Waste	0-100	0. 8	
Transport	0-100	0. 9	
Total			

Table 11. GRIHA LD - Final Design Impact - Qualitative[96]

Final Design Impact - Qualitative				
Section	Point score	Qualitative Impact (from 0 to 100%) (Q_l)	Normalizing multiplier (M)	Final impact score in each section (I_q)
Site Planning	0	0-100	0. 9	Σ($I_q = Q_l$ X M) [97]
Energy	0	0-100	1. 0	
Water	0	0-100	1. 0	
Waste	0	0-100	0. 8	
Transport	0	0-100	0. 9	
Total				

[94] ((ADARSH) Association for Development and Reaserach of Sustainable Habitats 2013), 12.

[95] The Final Design Impact Quantitative score in each section is the product of the Quantitative Impact percentage and the normalizing multiplier. The least amount of impact is desirable.

[96] ((ADARSH) Association for Development and Reaserach of Sustainable Habitats 2013), 13.

[97] The Final Design Impact Qualitative score in each section is the product of the Qualitative Impact percentage and the normalizing multiplier. The least amount of impact is desirable.

The Overall impact of both the quantitative and the qualitative impacts on the environment are calculated using the following formula:

$I_t = I_n$ (design case) + I_q (design case) x 100 / I_n (base case) + I_q (base case)

Where, I_t = Overall Impact; I_n = Quantitative Impact; I_q = Qualitative Impact

The final rating is based on the Overall impact (I_t) of the project.

Overall Impact - I_t	Rating
75%-66%	One star
65%-56%	Two stars
55%-46%	Three stars
45%-36%	Four stars
35%-25%	Five stars

GRIHA PRAKRITI [98]

This rating system helps to evaluate the sustainability of the existing day schools that are non-residential. It had 16 criteria which are broadly divided into 6 categories: energy, comfort, water, trees, solid waste, management, and social. Each category has some mandatory points to be achieved. The maximum number of points is 50 and the rating is done on a 1-5 star scale.

[98] http://www.grihaindia.org/index.php?option=com_content&view=article&id=116&t=Green_Rating_for_Integrated_Habitat_Assessment

Points achieved	SVAGRIHA Rating
25-29	One star
30-34	Two stars
35-39	Three stars
40-45	Four stars
45-50	Five stars

3.2.6.3. CERTIFICATION PROCESS:

Even though the recommended stage for registering a project for the GRIHA certification is at the design phase, projects in the construction phase can apply if they succeed in demonstrating compliance with the mandatory GRIHA criteria. Documents delineating the compliance regulations can be found on the GRIHA website.

The GRIHA certification process is fairly rigorous and involves at least five different evaluating entities. After an online registration process, the parties involved in the project have the option of availing of an orientation workshop by the GRIHA Council. The submission of documents is also online. The GRIHA Council carries out the first evaluation of the project and gives appropriate comments. The second evaluation is conducted by subject specific evaluators who ask the clients for any required clarifications. The final evaluation is done by designated evaluators after which the GRIHA Council compiles the score. A provisional rating is awarded by the NAC ((National Advisory Council). This is followed by a performance and energy audit by a BEE (Bureau of Energy Efficiency) accredited auditor. The GRIHA Council evaluates this audit report and then the NAC awards the project the final rating.[99]

[99] http://www.grihaindia.org/index.php?option=com_content&view=article&id=88

3.2.6.4. FOCUS ON HISTORIC PRESERVATION

At present, the GRIHA rating system does not have a separate system for existing buildings, historic or otherwise (except for the recently announced GRIHA Prakriti for existing day schools). It is applicable exclusively to newly constructed buildings.

3.3. CONCLUSION

There are many green-building rating systems in use all around the world, with more being added all the time. One of the relatively new systems, the Living Building Challenge, seems to be very interesting and quite rigorous in its application. New versions of older systems, too, are launched periodically. The new LEED v4 was launched in 2013 whereas the BREEAM Non-Domestic Refurbishment 2014 was launched in 2015. LEED and BREEAM have been around for a long time and have led the field in promoting the use of new technology and its commissioning as well as in evaluating the impacts of the overall construction process from site evaluation to waste management. HQE is another system that has an emphasis on project management with a very robust post-completion, project monitoring component. The Indian system of GRIHA focuses on, both, the Quantitative as well as the Qualitative impact assessment of the project. Finally, as we have seen earlier, SKA provides a rating system for interior refurbishment schemes and is adaptable to the parameters of a particular project.

All these different systems have similarities since they are all focused on minimizing the impact of the building industry on the earth's environment. But, as we have seen earlier through our brief overview of a few systems, the umpteen classification systems, the varied emphasis on the different aspects of the construction processes, the multitude of methodologies for calculating the impacts and the resultant linguistic diversity make for a complex web of probably well-meaning but for the consumer a definitely confusing array of choices. Nonetheless, it does offer a consumer with multiple choices. Whether too many choices create more confusion or provide better flexibility would be a topic for further study.

After taking this overview, a choice of two green-building rating systems had to be made for the evaluation of the case study in the next chapters. SKA was chosen first as it was perceived as being more amenable for application to existing structures. The other choice was always between BREEAM and HQE since GRIHA was not under consideration as it is applicable only to new construction and therefore, not useful for historic structures. BREEAM was chosen for the reason that it has been used for rating many Historic Structures previously. LEED was the third system, by default, as the case study, the Fernow Hall project at Cornell University, is a LEED Gold certified project and the data available was collected and calculated for the LEED 2009 green-building rating system.

CHAPTER FOUR: CASE STUDY - FERNOW HALL, CORNELL UNIVERSITY AS A LEED GOLD CERTIFIED PROJECT

4.1. INTRODUCTION

Fernow Hall is a Colonial Revival style building at Cornell University presently housing the Department of Natural Resources. It was designed by Green and Wicks and constructed from 1912-1914. It was named after a former Dean of Cornell University, Bernhard Fernow. In 1984, the building was listed on the National Register of Historic Places. In 2014 the Fernow Hall Rehabilitation and Expansion project received LEED Gold certification.[100]

[100] (di Domenico + Partners, LLP 2014)

4.2. LOCATION AND SETTING

The location is on a hillside with the sloping site sloping. It is accessed from Tower road.

Figure 5. Location of Fernow Hall in the Cornell University Campus[101]

Figure 6. Birds eye view of Fernow Hall looking northwards on the Cornell University Campus[102]

[101] https://www.google.com/maps
[102] https://www.google.com/maps

4.3. GREEN BUILDING CERTIFICATION AT CORNELL

In 2005, Cornell University started work on preparing a comprehensive master plan for the Cornell University Ithaca Campus and by 2008 it had been formulated and approved by the Board of Trustees.[103] The aim of the Master plan was to make the campus more open, green, compact, integrated, connected and engaged.[104] Some of the main highlights of this Plan were: the Lake Source Cooling Project and the Combined Heat and Power Project that lowered the energy consumption, an acclaimed transportation demand management program, the establishment of an Office of Environmental Compliance and Sustainability and the implementation of Cornell Green Building Guidelines as well as the adoption of LEED certification programs for new buildings and some Existing building undergoing major renovations.[105] In 2008, the Cornell Board of Trustees gave approval to the proposal that all new building projects at Cornell which exceeded $5 million in cost would have to achieve a target of LEED 'Silver'[106] and that these projects would have to achieve a minimum of 30% energy savings in concordance with the baseline established by the ASHRAE 90.1 standard as of August 2015.[107] As of July 2015, Cornell had ten 'Gold' and two 'Platinum' LEED certified buildings on its campus, one of which is Fernow Hall, rated 'Gold'.[108]

Other than LEED certifications, other sustainable initiatives are also a big part of the Cornell University green initiative. Recently the 'Kroch Library Energy Conservation Initiative (ECI) Project' by Mark Howe won an EBie™ Award (EE-bees, short for Existing Buildings) in the category "Power to

[103] (Campus Sustainability Office, Sustainable Campus - Buildings n.d.), 2.
[104] (Campus Planning Office, CORNELL MASTER PLAN FOR THE ITHACA CAMPUS – PART 1: OVERALL PLAN:Vision 2008), 27.
[105] (Campus Planning Office, CORNELL MASTER PLAN FOR THE ITHACA CAMPUS – PART 1: OVERALL PLAN:Vision 2008), 34.
[106] (Campus Sustainability Office, Sustainable Campus - Buildings n.d.), 1.
[107] (Campus Sustainability Office, Green Buildings n.d.), 1.
[108] (Campus Sustainability Office, Sustainable Campus - Buildings n.d.), 1.

the People: Exceptional Energy Savings".[109] The project demonstrated a 21% decrease in energy usage.[110]

4.4. FERNOW HALL PROJECT BACKGROUND

The total gross square footage of Fernow Hall is 28,333 with 1701 square feet (6%) new construction and 26,632 square feet of existing building renovation. The total LEED project site area is 24,733 square feet.111 There are four floors above grade and one below grade.

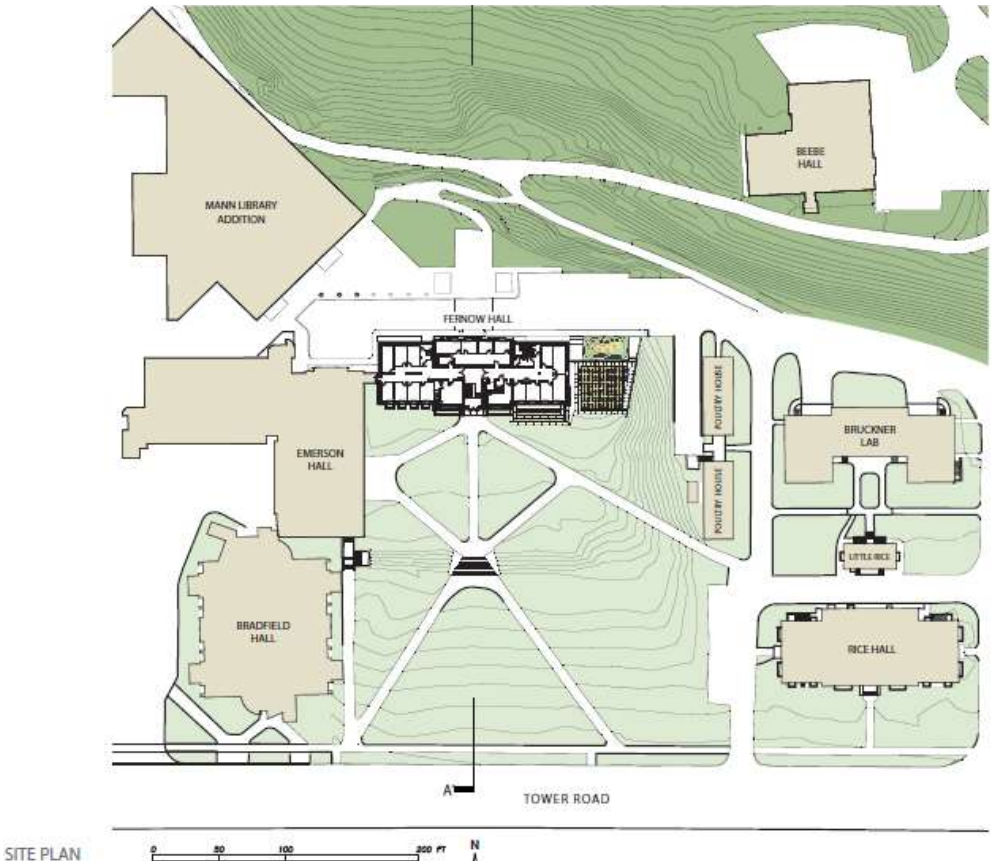


Figure 7. Site Plan[112]

[109] (Campus Sustainability Office, Cornell University 2015), 1.
[110] (University 2012), 1.
[111] (Harrell 2011), 1.
[112] (di Domenico + Partners n.d.)

The building is connected to the municipal potable water system and the municipal sewage system. It is connected to the city electricity grid and also uses energy from district/ campus heating and Lake Source cooling system and on-site renewables (PV panels).

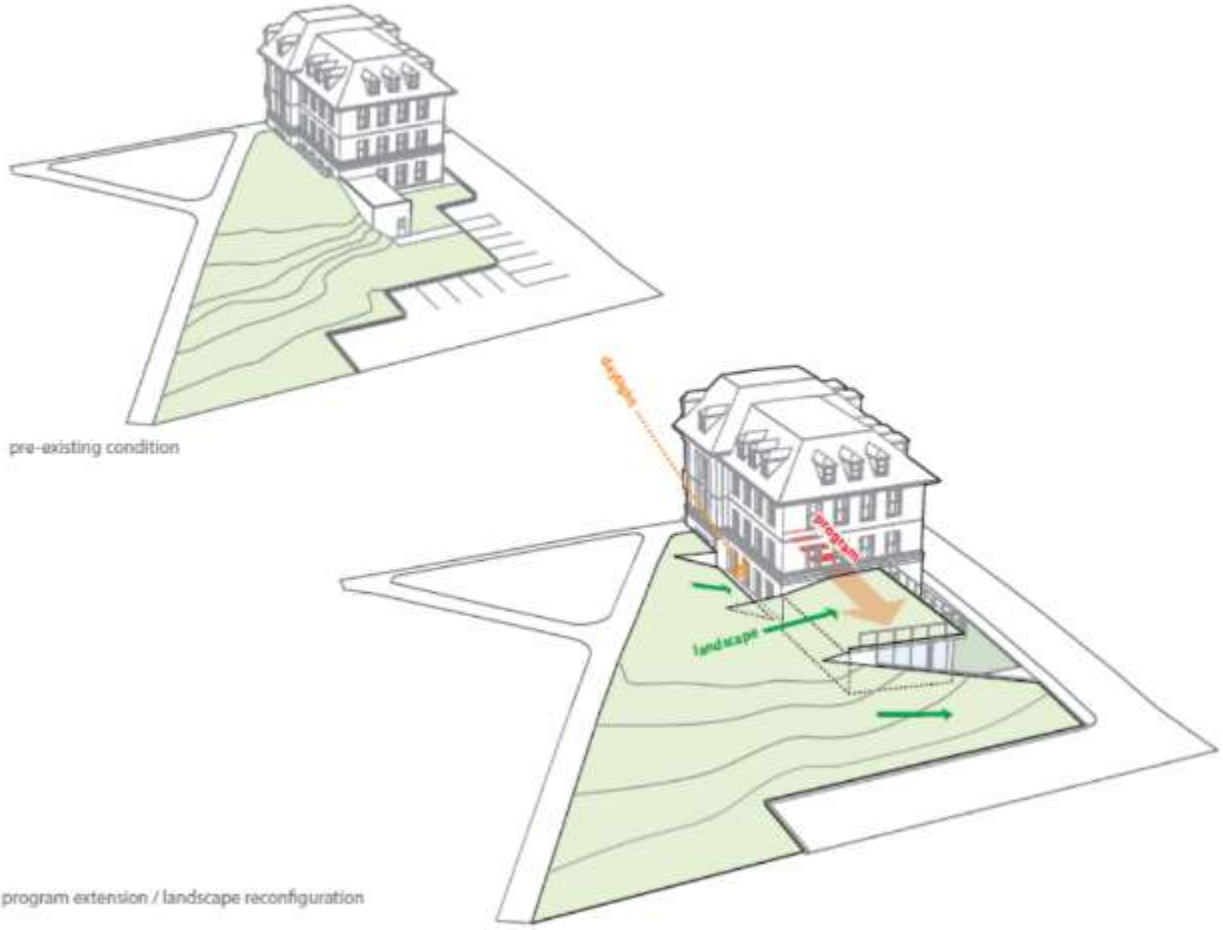


Figure 8. bird's eye perspective view rendering of the project looking towards east[113]

Here is a bird's eye perspective view rendering of the project looking towards east showing the earlier configuration and the new addition. The new classroom space with the planted roof terrace garden can be seen in this view.

[113] (di Domenico + Partners n.d.), 8.

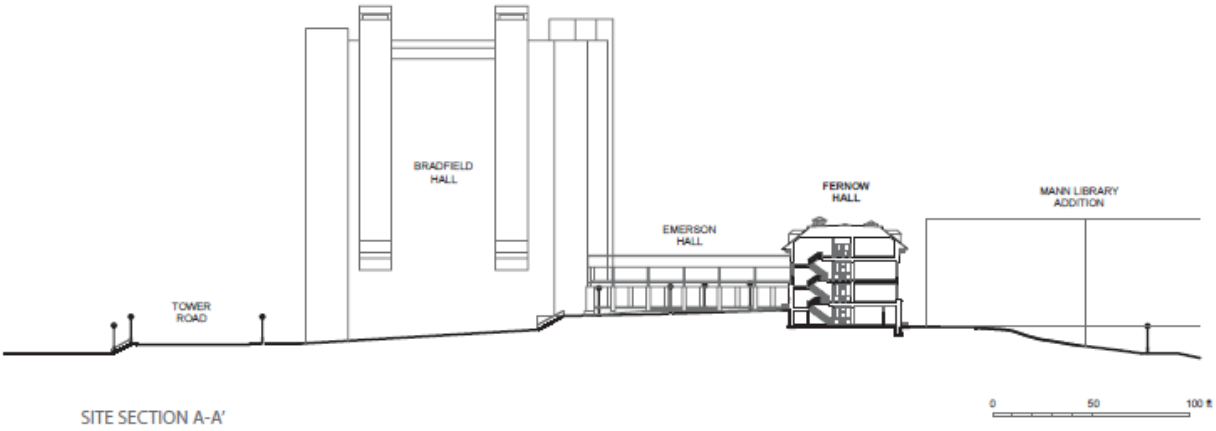


Figure 9. East-West Section[114]

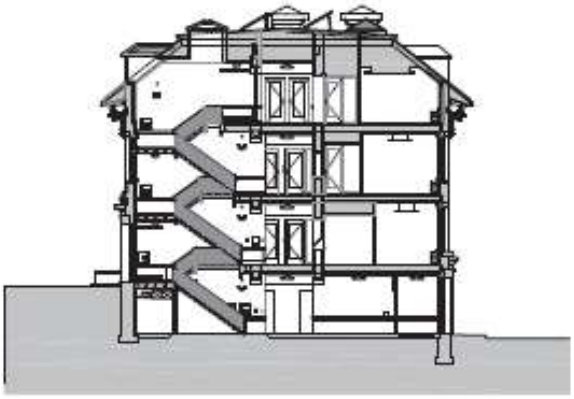


Figure 10. East-West Section

Figure 11. North-South through the new classroom addition

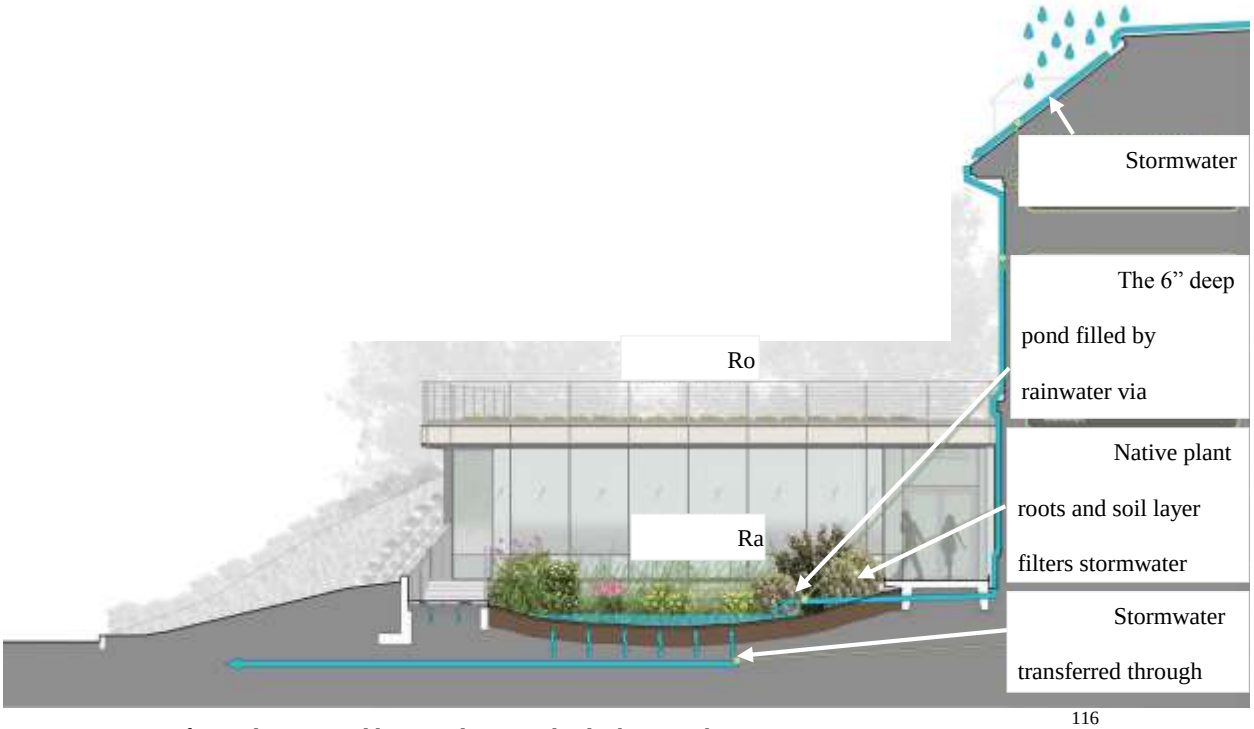
[114] Figures 5, 6, and 7. (di Domenico + Partners n.d.), 7.

Some of the sustainable-design features of the project are a planted roof terrace garden, a rain garden and the use of photovoltaic solar renewable energy systems.[115]

A rain garden was created directly north of the new 50-person classroom to mitigate storm water runoff. The garden contains a variety of self-sustaining vegetation.

The planted roof garden terrace sits on the roof of the new classroom addition. It contains a mix of sedum plantings and a possibility for experimental plantings by the Department of Natural Resources.

There are several photovoltaic solar renewable energy systems, one of which are solar photovoltaic glass skylights.



[116]

Figure 12. View of new classroom addition and rain garden looking north

[115] http://www.sustainablecampus.cornell.edu/initiatives/fernow-hall, 1.
[116] (di Domenico + Partners n.d.), 18.

4.5. PROJECT LEED CERTIFICATION DETAILS

The Fernow Hall project received a total of 66 points of the possible 110 to achieve the 'Gold' LEED certification in the LEED BD+C: New Construction (v2009) category.[117]

As discussed before, LEED has different categories under which points are awarded such as: Sustainable Sites, Water Efficiency, Energy & Atmosphere, Materials & Resources, Indoor Environmental Quality, Innovation & Design Process, and Regional Priority Credits. The credits are divided into two types: mandatory pre-requisites, that do not award any points and optional credits, that are attempted to gain points. We will take a detailed look at all these categories and the way in which the Fernow Hall project achieved points in each of them. The information is sourced from the Fernow Hall LEED Certification Review Report accessed from the LEED Online portal used for the project certification process.[118]

An important aspect of the LEED calculations is the FTE[119] (Full Time Equivalent) number which calculates the occupancy levels of the building. For the Fernow Hall project the FTE has been calculated as 109. The Peak transient occupancy value has been determined as 59.

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[117] Why LEED NC (New Construction) and not LEED O+M (Operations and Maintenance)? As seen earlier, LEED certification for Operations and Management the LEED certification for New Construction is also applicable to Major Renovations. It is more probable that an application for a LEED certification of a Historic Building would be considered, more often than not, when it is undergoing rehabilitation. As we see with the case study, Fernow Hall at Cornell University applied for and received a LEED NC (New Construction) Gold certification since the historic structure underwent a major renovation during the project.

[118] (USGBC 2014), 1.

[119] To differentiate between the various types of people visiting a LEED building and to adapt the building systems to their needs, they are sorted into two main categories: regular building occupants consisting of employees, staff, residents, school students, hotel guests and inpatients; and visitors consisting of retail customers, outpatients and higher education students. For the first category, the regular building occupants, in order to normalize the occupancy hours of full-time and part-time occupants, the FTE (Full-time Equivalency) is calculated using certain formulae as proposed by LEED. (USGBC, LEED v4 User Guide 2014), 17.

A. SUSTAINABLE SITES

This category focuses on the impact of site selection and its treatment on the overall sustainability of the project. The Fernow Hall Project received 19 points out of the possible 26. We will take a detailed look at each of the credits.

SSP1 CONSTRUCTION ACTIVITY POLLUTION PREVENTION

This is a pre-requisite which is mandatory. It does not award any point. An Erosion and Sedimentation Control (ESC) Plan conforming with the local standards and codes was implemented during the construction phase. An ESC Plan describes the steps to be taken to prevent soil loss, sedimentation, and pollution of the air.

SSC1 SITE SELECTION

The intent of this credit is "To avoid the development of environmentally sensitive lands and reduce the environmental impact from the location of a building on a site."[120] Since the project is largely the refurbishment of an existing building and the addition is not located on an environmentally sensitive piece of land such as farmland or parkland, this credit was fulfilled.

SSC2 DEVELOPMENT DENSITY AND COMMUNITY CONNECTIVITY

The intent of this credit is "To channel development to urban areas with existing infrastructure, protect Greenfields and preserve habitat and natural resources."[121] The project site is located within 0.5 miles of at least 10 community services as well as a residential district with a minimum density of 10 units per acre, which fulfills the requirements of Option 2: Community connectivity. This gives the project five points.122

[120] http://www.usgbc.org/node/1731738?return=/credits/new-construction/v2009
[121] http://www.usgbc.org/node/1731847?return=/credits/new-construction/v2009&view=language
[122] (USGBC 2014)

SSC3 BROWNFIELD REDEVELOPMENT

The intent of this credit is "To rehabilitate damaged sites where development is complicated by environmental contamination and to reduce pressure on undeveloped land."[123] The site was found to be contaminated by asbestos and as such the plan for its removal and disposal was prepared by AECOM, a professional and technical services firm. This plan included the specifications for site remediation.

SSC4.1 ALTERNATIVE TRANSPORTATION-PUBLIC TRANSPORTATION ACCESS

The intent of this credit is "To reduce pollution and land development impacts from automobile use."[124] The presence of at least 2 bus lines located within 0.25 miles of the project site fulfills the requirements for Option 2: Bus stop proximity. This gives the project 6 points.

SSC4.2 ALTERNATIVE TRANSPORTATION-BICYCLE STORAGE AND CHANGING ROOMS

The intent of this credit is "To reduce pollution and land development impacts from automobile use."[125] The project FTE is 109 and the Peak transient occupancy value is 59. The project site provides bicycle storage to 9.52% FTE and Peak transient occupants the requirement being 5%. Onsite shower facilities are provided for 1. 83% of the FTE Occupants the requirement being 0.5%. This fulfills the requirements for commercial buildings and awards the project 1 point.

SSC4.3 ALTERNATIVE TRANSPORTATION-LOW-EMITTING AND FUEL-EFFICIENT VEHICLES

The intent of this credit is "To reduce pollution and land development impacts from automobile use."[126] This credit was not attempted.

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[123] http://www.usgbc.org/node/1732046?return=/credits/new-construction/v2009&view=language
[124] http://www.usgbc.org/node/1731944?return=/credits/new-construction/v2009&view=language
[125] http://www.usgbc.org/node/1731996?return=/credits/new-construction/v2009&view=language
[126] http://www.usgbc.org/node/1732305?return=/credits/new-construction/v2009&view=language

SSC4.4 ALTERNATIVE TRANSPORTATION-PARKING CAPACITY

The intent of this credit is "To reduce pollution and land development impacts from automobile use."[127] The project provides no new parking. This satisfies the requirements for this credit. This provides the project with 2 points.[128]

SSC5.1 SITE DEVELOPMENT-PROTECT OR RESTORE HABITAT

The intent of this credit is "To conserve existing natural areas and restore damaged areas to provide habitat and promote biodiversity."[129] This credit was not attempted.

SSC5.2 SITE DEVELOPMENT-MAXIMIZE OPEN SPACE

The intent of this credit is "To promote biodiversity by providing a high ratio of open space to development footprint."[130] The requirements of this credit state that sites with no local zoning requirements such as certain university campuses (Cornell University Ithaca Campus being one such campus) have to provide vegetated open space area adjacent to the building that is equal in area to the building footprint.[131] Additionally for all projects in urban areas that have earned the SS Credit 2: Development Density and Community Connectivity, vegetated roof areas can contribute to credit compliance.[132] The Fernow Hall project has provided an open space larger than the building footprint, including the vegetative roof surface over the new addition. This provides the project with 1 point.[133]

SSC6.1 STORMWATER DESIGN-QUANTITY CONTROL

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[127] http://www.usgbc.org/node/1731015?return=/credits/new-construction/v2009&view=language

[128] The project also gets 1 additional point due to this action in the Innovation in Design Category explained later in the document.

[129] http://www.usgbc.org/node/1731477?return=/credits/new-construction/v2009&view=language

[130] http://www.usgbc.org/node/1731541?return=/credits/new-construction/v2009&view=language

[131] http://www.usgbc.org/node/1731541?return=/credits/new-construction/v2009/sustainable-sites

[132] http://www.usgbc.org/node/1731541?return=/credits/new-construction/v2009/sustainable-sites

[133] The project also gets 1 additional point due to this action in the Innovation in Design Category explained later in the document.

The intent of this credit is "To limit disruption of natural hydrology by reducing impervious cover, increasing on-site infiltration, reducing or eliminating pollution from storm water runoff and eliminating contaminants."[134] This credit was not attempted.

SSC6.2 STORMWATER DESIGN-QUALITY CONTROL

The intent of this credit is "To limit disruption and pollution of natural water flows by managing storm water runoff"[135] This credit was not attempted.

SSC7.1 HEAT ISLAND EFFECT, NON-ROOF

The intent of this credit is "To reduce heat islands to minimize impacts on microclimates and human and wildlife habitats."[136] As per the requirements of Option 1 for this credit (minimum required 50%), 51.9% of non-roof based building hardscape surfaces would have materials with an SRI (Solar Reflectance Index) of at least 29 or will be shaded by landscaping or trees within five years.

SSC7.2 HEAT ISLAND EFFECT-ROOF

The intent of this credit is "To reduce heat islands1 to minimize impacts on microclimates and human and wildlife habitats."[137] This credit was not attempted.

SSC8 LIGHT POLLUTION REDUCTION

The intent of this credit is "To minimize light trespass from the building and site, reduce sky-glow to increase night sky access, improve nighttime visibility through glare reduction and reduce development impact from lighting on nocturnal environments."[138] According to the Cornell LEED team administration[139], the interior and exterior lighting was designed in compliance with the requirements of

[134] http://www.usgbc.org/node/1731618?return=/credits/new-construction/v2009&view=language
[135] http://www.usgbc.org/node/1731621?return=/credits/new-construction/v2009&view=language
[136] http://www.usgbc.org/node/1731021?return=/credits/new-construction/v2009&view=language
[137] http://www.usgbc.org/node/1731100?return=/credits/new-construction/v2009&view=language
[138] http://www.usgbc.org/node/1730917?return=/credits/new-construction/v2009&view=language
[139] The Cornell LEED team for the Fernow Hall project was led by Matthew Kozlowski, LEED AP.

this credit and a Licensed Professional Exemption was claimed by the licensed professional designer in place of providing calculations and supporting documentation.

FINAL SCORE IN CATEGORY

Table 12. Fernow Hall LEED score[140]

SUSTAINABLE SITES	19 of 26
SSp1 Construction Activity Pollution Prevention	Y
SSc1 Site Selection	1 / 1
SSc2 Development Density and Community Connectivity	5 / 5
SSc3 Brownfield Redevelopment	1 / 1
SSc4.1 Alternative Transportation-Public Transportation Access	6 / 6
SSc4.2 Alternative Transportation-Bicycle Storage and Changing Rooms	1 / 1
SSc4.3 Alternative Transportation-Low-Emitting & Fuel-Efficient Vehicles	0 / 3
SSc4.4 Alternative Transportation-Parking Capacity	2 / 2
SSc5.1 Site Development-Protect or Restore Habitat	0 / 1
SSc5.2 Site Development-Maximize Open Space	1 / 1
SSc6.1 Stormwater Design-Quantity Control	0 / 1
SSc6.2 Storm water Design-Quality Control	0 / 1
SSc7.1 Heat Island Effect, Non-Roof	1 / 1
SSc7.2 Heat Island Effect-Roof	0 / 1
SSc8 Light Pollution Reduction	1 / 1

[140] (USGBC n.d.)

B. WATER EFFICIENCY

WEp1 Water Use Reduction-20% Reduction

The intent of this credit is "To increase water efficiency within buildings to reduce the burden on municipal water supply and wastewater systems."[141] According to documents submitted by the Cornell LEED team administration, the use of potable water has been reduced by 38.16% from a calculated baseline design through measures such as installation of low-flow water closets, low-flow urinals, and low-flow lavatory faucets etc.

WEc1 Water Efficient Landscaping

The intent of this credit is "To limit or eliminate the use of potable water or other natural surface or subsurface water resources available on or near the project site for landscape irrigation."[142] The landscape for the new addition was designed for no irrigation and, as such, no permanent irrigation system was installed which satisfies the requirements for Option 2 of the credit.

WEc2 Innovative Wastewater Technologies

The intent of this credit is "To reduce wastewater generation and potable water demand while increasing the local aquifer recharge."[143] This credit was not attempted.

WEc3 Water use reduction

The intent of this credit is "To further increase water efficiency within buildings to reduce the burden on municipal water supply and wastewater systems."[144] The requirements to satisfy this credit are given in the table below.

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[141] http://www.usgbc.org/node/1732070?return=/credits/new-construction/v2009&view=language
[142] http://www.usgbc.org/node/1732728?return=/credits/new-construction/v2009&view=language
[143] http://www.usgbc.org/node/1732131?return=/credits/new-construction/v2009&view=language
[144] http://www.usgbc.org/node/1732111?return=/credits/new-construction/v2009&view=language

Table 13 Points table for LEED Credit WEc3 Water use reduction[145]

% Reduction in water usage	Points awarded
30	2
35	3
40	4

As mentioned earlier, the use of potable water has been reduced by 38. 16% from a calculated baseline design. So the project received 3 points for this credit.

FINAL SCORE IN CATEGORY

Table 14. Fernow Hall LEED score[146]

WATER EFFICIENCY	7 OF 10
WEp1 Water Use Reduction-20% Reduction	Y
WEc1 Water Efficient Landscaping	4 / 4
WEc2 Innovative Wastewater Technologies	0 / 2
WEc3 Water use reduction	3 / 4

C. ENERGY & ATMOSPHERE

EAp1 Fundamental commissioning of building energy system

The intent of this credit is "To verify that the project's energy-related systems are installed, calibrated and perform according to the owner's project requirements, basis of design and construction

[145] http://www.usgbc.org/node/1732111?return=/credits/new-construction/v2009/water-efficiency&view=language

[146] (USGBC n.d.)

documents."[147] The Cornell LEED team administration provided a Fundamental Commissioning Report as well as the credentials of the Commissioning agent. Additionally, the Commissioning agent has verified that the Owner's Project Requirements (OPR) and Basis of Design (BOD) are consistent with the final construction documentation and completed project. Thus this pre-requisite has been fulfilled.

EAp2 Minimum energy performance

The intent of this mandatory pre-requisite is "To establish the minimum level of energy efficiency for the proposed building and systems to reduce environmental and economic impacts associated with excessive energy use."[148] According to documents submitted by the Cornell LEED team administration, the project has reached an energy cost savings of 22.54% while using the ASHRAE Standard 90.1-2007. It fulfilled the requirements for the Treatment of District or Campus Thermal Energy in LEED V2 and LEED 2009-Design and Construction guidelines.[149]

EAp3 Fundamental refrigerant management

The intent of this mandatory pre-requisite is "To reduce stratospheric ozone depletion."[150] The Lake Source Cooling water systems have been used for reducing temperatures and is essentially CFC-Free, which is a requirement for this credit. The documentation provided fulfills the requirements as specified in the LEED Reference Guide for Building Design and Construction, 2009 Edition[151], and the Treatment of District or Campus Thermal Energy in LEED v2 and LEED 2009 Design and Construction document.[152]

EAc1 Optimize energy performance

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[147] http://www.usgbc.org/node/1731178?return=/credits/new-construction/v2009&view=language
[148] http://www.usgbc.org/node/1731017?return=/credits/new-construction/v2009&view=language
[149] (USGBC, Treatment of District or Campus Thermal Energy in LEED 2010) , 9-15.
[150] http://www.usgbc.org/node/1731226?return=/credits/new-construction/v2009&view=language
[151] http://www.usgbc.org/node/1731226?return=/credits/new-construction/v2009/energy-&-atmosphere&view=language
[152] (USGBC, Treatment of District or Campus Thermal Energy in LEED 2010), 16-17.

The intent of this credit is "To achieve increasing levels of energy performance beyond the prerequisite standard to reduce environmental and economic impacts associated with excessive energy use."[153] As mentioned earlier, the project has reached an energy cost savings of 22.54% while using the ASHRAE Standard 90.1-2007. This gives the project additional 8 points according to the Credit Compliance guidelines.[154]

EAc2 On-site renewable energy

The intent of this credit is "To encourage and recognize increasing levels of on-site renewable energy self-supply to reduce environmental and economic impacts associated with fossil fuel energy use."[155] Through the use of roof mounted PV Panels and PV Skylight Film, the renewable energy generated offsets 1. 36% of the total annual energy cost. According to the LEED 2009[156] requirements this awards the project 1 point.

EAc3 Enhanced commissioning

The intent of this credit is "To begin the commissioning process early in the design process and execute additional activities after systems performance verification is completed."[157] The Fernow Hall team submitted the required documentation including the completion dates for the comprehensive commissioning review tasks endorsed by the project's Commissioning Agent. The Systems manual contained data about the commissioned systems, system operating instructions for each of the building systems, and future operating information as well as the contract between the Owner and the Commissioning Agent ensuring post-construction commissioning activities. This satisfied the credit requirements.

[153] http://www.usgbc.org/node/1731022?return=/credits/new-construction/v2009&view=language
[154] http://www.usgbc.org/node/1731022?return=/credits/new-construction/v2009/energy-&view=language
[155] http://www.usgbc.org/node/1731246?return=/credits/new-construction/v2009&view=language
[156] http://www.usgbc.org/node/1731246?return=/credits/new-construction/v2009/energy-&view=language
[157] http://www.usgbc.org/node/1731181?return=/credits/new-construction/v2009&view=language

EAc4 Enhanced refrigerant Management

The intent of this credit is "To reduce ozone depletion and support early compliance with the Montreal Protocol while minimizing direct contributions to climate change."[158] The fundamental refrigerant management data and mechanical schedules the project demonstrate that all applicable downstream and upstream equipment meet the credit requirements as specified in the Treatment of District or Campus Thermal Energy in LEED V2 and LEED 2009-Design and Construction guidelines.[159]

EAc5 Measurement and verification

The intent of this credit is "To provide for the ongoing accountability of building energy consumption over time."[160] The project fulfills the requirements by meeting the Minimum Program Requirement 6 through compliance with the Option 1: Energy and Water Data Release Form. The project also needs to get an account with the Portfolio Manager tool of ENERGY STAR[161] and share that file with the USGBC master account.

EAc6 Green power

The intent of this credit is "To encourage the development and use of grid-source, renewable energy technologies on a net zero pollution basis."[162] This credit was not attempted.

[158] http://www.usgbc.org/node/1731231?return=/credits/new-construction/v2009&view=language
[159] (USGBC, Treatment of District or Campus Thermal Energy in LEED 2010) , 16-17.
[160] http://www.usgbc.org/node/1731215?return=/credits/new-construction/v2009&view=language
[161] Energy Star program, established in 1992 by the EPA for the Clean Air Act Section 103(g) of the Clean Air Act, promotes energy efficiency through a voluntary process. **Invalid source specified.**, 1.
[162] http://www.usgbc.org/node/1731298?return=/credits/new-construction/v2009&view=language

FINAL SCORE IN CATEGORY

Table 15. Fernow Hall LEED score[163]

ENERGY & ATMOSPHERE	16 OF 35
EAp1 Fundamental commissioning of building energy system	Y
EAp2 Minimum energy performance	Y
EAp3 Fundamental refrigerant management	Y
EAc1 Optimize energy performance	8 / 19
EAc2 On-site renewable energy	1 / 7
EAc3 Enhanced commissioning	2 / 2
EAc4 Enhanced refrigerant management	2 / 2
EAc5 Measurement and verification	3 / 3
EAc6 Green power	0 / 2

D. MATERIAL & RESOURCES

MRp1 Storage and collection of recyclables

The intent of this credit is "To facilitate the reduction of waste generated by building occupants that is hauled to and disposed of in landfills."[164] The project fulfills the requirements through actions such as providing dedicated areas for the collection and storage of recyclable materials including cardboard, paper, plastic, glass, and metals. A University recycling narrative has been provided to USGBC.

MRc1.1 Building reuse - maintain existing walls, floors and roof

[163] (USGBC n.d.), 1.
[164] http://www.usgbc.org/node/1731263?return=/credits/new-construction/v2009&view=language

The intent of this credit is "To extend the life cycle of existing building stock, conserve resources, retain cultural resources, reduce waste and reduce environmental impacts of new buildings as they relate to materials manufacturing and transport."[165] Since majority of the project consisted of refurbishing the existing Fernow Hall building, about 79.6% of the existing structural elements have been reused and this gives the project 2 points.

Table 16. Minimum percentage building reuse for each point threshold LEED Credit MRc1.1 Building reuse - maintain existing walls, floors and roof [166]

Building Reuse	Points
55%	1
75%	2
95%	3

MRc1. 2 Building reuse - maintain interior nonstructural elements

The intent of this credit is "To extend the life cycle of existing building stock, conserve resources, retain cultural resources, reduce waste and reduce environmental impacts of new buildings as they relate to materials manufacturing and transport."[167] This credit was not attempted.

MRc2 Construction waste Management

The intent of this credit is "to divert construction and demolition debris from disposal in landfills and incineration facilities. Redirect recyclable recovered resources back to the manufacturing process and reusable materials to appropriate sites."[168] According to the documentation provided, 73.78% of the

[165] http://www.usgbc.org/node/1731328?return=/credits/new-construction/v2009&view=language
[166] http://www.usgbc.org/node/1731328?return=/credits/new-construction/v2009/material-%26-resources
[167] http://www.usgbc.org/node/1731348?return=/credits/new-construction/v2009&view=language
[168] http://www.usgbc.org/node/1731280?return=/credits/new-construction/v2009&view=language

on-site generated construction waste was diverted from going to a landfill and so, one point was awarded to the project.

Table 17. Minimum percentage debris to be recycled or salvaged for each point threshold, LEED Credit MRc2 Construction waste management[169]

Recycled or Salvaged	Points
50%	1
75%	2

MRC3 MATERIALS REUSE

The intent of this credit is "To reuse building materials and products to reduce demand for virgin materials and reduce waste, thereby lessening impacts associated with the extraction and processing of virgin resources."[170] This credit was not attempted.

MRC4 RECYCLED CONTENT

The intent of this credit is "To increase demand for building products that incorporate recycled content materials, thereby reducing impacts resulting from extraction and processing of virgin materials."[171] About 11.49% of the total building materials content, by value, has been manufactured using recycled materials as per the LEED Credit Form and the LEED Materials and Resource Calculator that was filled in by the LEED project team. The recycled materials used meet the ISO 14021 definitions of post- and pre-consumer material. This gave the team 1 point.

[169] http://www.usgbc.org/node/1731280?return=/credits&view=language
[170] http://www.usgbc.org/node/1731020?return=/credits/new-construction/v2009&view=language
[171] http://www.usgbc.org/node/1731024?return=/credits/new-construction/v2009&view=language

Table 18. Minimum percentage materials reused for each point threshold LEED Credit MRc4 Recycled content[172]

Reused Materials	Points
10%	1
20%	2

MRc5 Regional materials

The intent of this credit is "To increase demand for building materials and products that are extracted and manufactured within the region, thereby supporting the use of indigenous resources and reducing the environmental impacts resulting from transportation."[173]

About 29.46% of the total building materials value consists of building materials and products manufactured or extracted within 500 miles of the project site. This gave the team 2 points.

Table 19. Minimum percentage regional materials for each point threshold LEED Credit MRc5 Regional materials[174]

Regional Materials	Points
10%	1
20%	2

MRc6 Rapidly renewable materials

[172] http://www.usgbc.org/node/1731024?return=/credits&view=language
[173] http://www.usgbc.org/node/1731029?return=/credits/new-construction/v2009&view=language
[174] http://www.usgbc.org/node/1731029?return=/credits&view=language

The intent of this credit is "To reduce the use and depletion of finite raw materials and long-cycle renewable materials by replacing them with rapidly renewable materials." [175] This credit was not attempted.

MRc7 Certified wood 1 / 1

The intent of this credit is "To encourage environmentally responsible forest management."[176]

According to the LEED Credit Form and the LEED Materials and Resource Calculator that was filled in by the LEED project team, 67.94% of the total wood-based building materials are certified in accordance with the principles and criteria of the Forest Stewardship Council (FSC). The minimum requirement for this credit is 50%, which was fulfilled.[177]

FINAL SCORE IN CATEGORY

Table 20. Fernow Hall LEED score[178]

MATERIAL & RESOURCE	7 / 14
MRp1 Storage and collection of recyclables	Y
MRc1.1 Building reuse - maintain existing walls, floors and roof	2 / 3
MRc1.2 Building reuse - maintain interior nonstructural elements	0 / 1
MRc2 Construction waste Mgmt 1 / 2	1 / 2
MRc3 Materials reuse	0 / 2
MRc4 Recycled content	1 / 2
MRc5 Regional materials	2 / 2
MRc6 Rapidly renewable materials	0 / 1
MRc7 Certified wood	1 / 1

[175] http://www.usgbc.org/node/1731030?return=/credits/new-construction/v2009&view=language, Rapidly renewable materials must have a harvest cycle of 10 years or less. They include materials such as bamboo, and agrifibers.

[176] http://www.usgbc.org/node/1731359?return=/credits/new-construction/v2009&view=language

[177] http://www.usgbc.org/node/1731359?return=/credits&view=language

[178] (USGBC 2014)

E. INDOOR ENVIRONMENTAL QUALITY

EQp1 Minimum indoor air quality performance

The intent of this credit is "To establish minimum indoor air quality (IAQ) performance to enhance indoor air quality in buildings, thus contributing to the comfort and well-being of the occupants."[179] According to the LEED Prerequisite form provided by the LEED Project team, the project is in compliance with the minimum requirements of ASHRAE Standard 62.1-2007, Ventilation for Acceptable Indoor Air Quality by using the Ventilation Rate Procedure. The Natural ventilation calculations provided demonstrate compliance with Paragraph 5.1 of ASHRAE Standard 62.1-2007.

EQp2 Environmental Tobacco Smoke (ETS) control

The intent of this credit is "To prevent or minimize exposure of building occupants, indoor surfaces and ventilation air distribution systems to environmental tobacco smoke (ETS)."[180] The required documentation, such as the photographs of non-smoking signage specifying that smoking is prohibited within 25 feet of entries, outdoor air intakes, and operable windows, has been forwarded to the LEED review team, thus fulfilling this prerequisite.

EQc1 Outdoor air delivery monitoring

The intent of this credit is "To provide capacity for ventilation system monitoring to help sustain occupant comfort and well-being."[181] This credit was not attempted.

EQc2 Increased ventilation

[179] http://www.usgbc.org/node/1732248?return=/credits/new-construction/v2009&view=language
[180] http://www.usgbc.org/node/1731149?return=/credits/new-construction/v2009&view=language
[181] http://www.usgbc.org/node/1731668?return=/credits/new-construction/v2009&view=language

The intent of this credit is "To provide additional outdoor air ventilation to improve indoor air quality (IAQ) for improved occupant comfort, well-being and productivity."[182] This credit was not attempted.

EQc3.1 Construction IAQ Management plan - during construction

The intent of this credit is "To reduce indoor air quality (IAQ) problems resulting from construction or renovation and promote the comfort and well-being of construction workers and building occupants."[183] The project documentation shows that the project team developed and implemented a Construction IAQ Management Plan according to the SMACNA Guidelines. This was endorsed by the Commissioning Agent. This gave the project 1 point.

EQc3.2 Construction IAQ Management plan - before occupancy

The intent of this credit is "To reduce indoor air quality (IAQ) problems resulting from construction or renovation to promote the comfort and well-being of construction workers and building occupants."[184] For Fernow Hall project, the IAQ (Indoor Air Quality) Management Plan was implemented along with post-construction measures. In this way the requirements for the Option 2 of this credit were satisfied. In the documentation, a Construction IAQ Management Plan and an IAQ testing report were attached.

EQc4.1 Low-emitting materials - adhesives and sealants

The intent of this credit is "To reduce the quantity of indoor air contaminants that are odorous, irritating and/or harmful to the comfort and well-being of installers and occupants."[185] All adhesive and sealant products used in the project complied with the VOC limits as specified in the credit requirements. Detailed tables are attached in Appendix Q.

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[182] http://www.usgbc.org/node/1731670?return=/credits/new-construction/v2009&view=language
[183] http://www.usgbc.org/node/1732334?return=/credits/new-construction/v2009&view=language
[184] http://www.usgbc.org/node/1732341?return=/credits/new-construction/v2009&view=language
[185] http://www.usgbc.org/node/1732510?return=/credits/new-construction/v2009&view=language

EQc4.2 Low-emitting MATERIALS - paints and coatings

The intent of this credit is "To reduce the quantity of indoor air contaminants that are odorous, irritating and/or harmful to the comfort and well-being of installers and occupants."[186] This credit was not attempted.

EQc4.3 Low-emitting materials - flooring systems

The intent of this credit is "To reduce the quantity of indoor air contaminants that are odorous, irritating and/or harmful to the comfort and well-being of installers and occupants."[187] This credit was not attempted.

EQc4.4 Low-emitting materials - composite wood and agrifiber products

The intent of this credit is "To reduce the quantity of indoor air contaminants that are odorous, irritating and/or harmful to the comfort and well-being of installers and occupants."[188] The project team has provided documentation in the form of a product summary stating that all composite wood, agrifiber products, and laminate adhesives used in the building do not contain any added urea-formaldehyde resins.

EQc5 Indoor chemical and pollutant source control

The intent of this credit is "To minimize building occupant exposure to potentially hazardous particulates and chemical pollutants."[189] The LEED Credit form states that indoor chemical and pollutant source control measures have been taken and that the installation of MERV 13 filtration media in all HVAC systems prior to occupancy, as required by this credit, has been accomplished. Additionally, the

[186] http://www.usgbc.org/node/1732511?return=/credits/new-construction/v2009&view=language
[187] http://www.usgbc.org/node/1732512?return=/credits/new-construction/v2009&view=language
[188] http://www.usgbc.org/node/1732513?return=/credits/new-construction/v2009&view=language
[189] http://www.usgbc.org/node/1732542?return=/credits/new-construction/v2009&view=language

documentation provided by the Project team consists of mechanical drawings highlighting the location of the chemical/hazardous gas usage areas, room separations, and associated exhaust systems.

EQc6.1 Controllability of systems - lighting

The intent of this credit is "To provide a high level of lighting system control by individual occupants or groups in multi-occupant spaces (e.g., classrooms and conference areas) and promote their productivity, comfort and well-being."[190] This credit requires that at least 90% of the building occupants should be able to make lighting adjustments to suit the individual task needs and preferences. The project provides the required lighting controls for 100% of the individual workstations and 100% of the shared occupant spaces thus satisfying this credit and earning 1 point.

EQc6.2 Controllability of systems - thermal comfort

The intent of this credit is "To provide a high level of thermal comfort system control by individual occupants or groups in multi-occupant spaces (e.g., classrooms or conference areas) and promote their productivity, comfort and well-being."[191] This credit requires that at least 50% of the building occupants should be able to make thermal comfort control adjustments to suit the individual needs and preferences. According to the documentation provided by the LEED team, the project provides the required thermal comfort controls for 100% of the individual workstations and 100% of the shared occupant spaces thus satisfying this credit and earning 1 point.

EQc7.1 Thermal comfort - design

The intent of this credit is "To provide a comfortable thermal environment that promotes occupant productivity and well-being."[192] This credit was not attempted.

EQc7.2 Thermal comfort – verification

[190] http://www.usgbc.org/node/1731102?return=/credits/new-construction/v2009&view=language
[191] http://www.usgbc.org/node/1731114?return=/credits/new-construction/v2009&view=language
[192] http://www.usgbc.org/node/1732365?return=/credits/new-construction/v2009&view=language

The intent of this credit is "To provide for the assessment of building occupant thermal comfort over time."[193] This credit was not attempted.

EQc8.1 Daylight and views - daylight

The intent of this credit is "To provide building occupants with a connection between indoor spaces and the outdoors through the introduction of daylight and views into the regularly occupied areas of the building."[194] According to the project documentation, out of the regularly occupied space (15,334 square feet) in the building, about 88.01% achieves the daylighting requirements. The minimum requirement is at least 75% of the regularly occupied spaces according to the Option 2 of the credit.[195]

EQc8.2 Daylight and views – views

The intent of this credit is "To provide building occupants a connection to the outdoors through the introduction of daylight and views into the regularly occupied areas of the building."[196] This credit was not attempted.

FINAL SCORE IN CATEGORY

Table 21. Fernow Hall LEED score[197]

INDOOR ENVIRONMENTAL QUALITY	8 / 15
EQp1	Y
EQp2	Y
EQc1 Outdoor air delivery monitoring	0 / 1
EQc2 Increased ventilation	0 / 1
EQc3. 1 Construction IAQ Mgmt plan - during construction	1 / 1

[193] http://www.usgbc.org/node/1732395?return=/credits/new-construction/v2009&view=language
[194] http://www.usgbc.org/node/1732569?return=/credits/new-construction/v2009&view=language
[195] http://www.usgbc.org/node/1732569?return=/credits/new-construction/v2009/indoor-environmental-quality&view=language
[196] http://www.usgbc.org/node/1732592?return=/credits/new-construction/v2009&view=language
[197] (USGBC n.d.)

EQc3. 2 Construction IAQ Mgmt plan - before occupancy	1 / 1
EQc4. 1 Low-emitting materials - adhesives and sealants	1 / 1
EQc4. 2 Low-emitting materials - paints and coatings	0 / 1
EQc4. 3 Low-emitting materials - flooring systems	0 / 1
EQc4. 4 Low-emitting materials - composite wood and agrifiber products	1 / 1
EQc5 Indoor chemical and pollutant source control	1 / 1
EQc6. 1 Controllability of systems - lighting	1 / 1
EQc6. 2 Controllability of systems - thermal comfort	1 / 1
EQc7. 1 Thermal comfort - design	0 / 1
EQc7. 2 Thermal comfort - verification	0 / 1
EQc8. 1 Daylight and views - daylight	1 / 1
EQc8. 2 Daylight and views - views	0 / 1

F. INNOVATION

IDc1 Innovation in design

The intent of these credits is "To provide design teams and projects the opportunity to achieve exceptional performance above the requirements set by the LEED Green Building Rating System and/or innovative performance in green building categories not specifically addressed by the LEED Green Building Rating System."[198] A maximum of 5 points are available in this section. The Fernow Hall team received 4. The details are discussed below.

IDc1. 1: Transportation Demand Management Program

[198]http://www.usgbc.org/node/1732608?return=/credits/new-construction/v2009&view=language

The project provides no new parking which satisfies the requirements for the Option 3 of the SSc4. 4: Alternative Transportation, Parking Capacity credit, thus getting 1 additional point in the Innovation in Design Category.

IDc1.2: Green Cleaning Program

This consists of purchase of green cleaning products and sustainable cleaning equipment as well as strategies for actions such as the promotion and improvement of hand hygiene, safe handling and storage of cleaning chemicals used in the building. The actions were in compliance with the LEED-EBOM 2009 IEQp3: Green Cleaning Policy which awarded the project 1 point.

IDc1.3: Green Building Education

According to this credit at least two educational initiatives such as e.g. an educational outreach program for occupants or the public by conducting periodic events related to green building topics, guided tours using the project as an example, a case-study discussing the successes of the LEED project, a website or electronic newsletter or comprehensive signage program, should be undertaken by the project team to earn the point. The Fernow Hall provided documentation for the development of a case-study and a guided tour program to comply with this credit.

IDc1.4: Integrated Pest Management

As per the documentation provided by the LEED project team, it has developed and implemented this Innovation in Design credit proposal in compliance with LEED-EBOM v2009 IEQc3. 6: Green Cleaning, Indoor Integrated Pest Management. It provided the LEED Review team with an Integrated Pest Management Plan that documents the project's best management practices.

IDc1.5: Take Back the Tap!

This innovative initiative consisted of installing bottle-filling stations across the campus to reduce the use of pre-filled bottled water. The reason the project did not receive this credit was, according to the

LEED Review team, that the initiative counted as a campus wide strategy which are not applicable as Innovation in Design credits.[199] The suggestion of the LEED Review team was to, in the future, demonstrate compliance by submitting calculations on an individual building level in concordance with the LEED Interpretation 2551 guidelines.

IDc2 LEED Accredited Professional

The intent of this credit is "To support and encourage the design integration required by LEED to streamline the application and certification process."[200] This credit requires that at least 1 principal participant of the project team has to be a LEED Accredited Professional (AP). Matthew Kozlowski, the Green Building Program Manager at Cornell University, was the LEED AP for this project team.

FINAL SCORE IN CATEGORY

Table 22. Fernow Hall LEED score[201]

INNOVATION	5 / 6
IDc1 Innovation in design	4 / 5
IDc2 LEED Accredited Professional	1 / 1

G. REGIONAL PRIORITY

RPC1 REGIONAL priority

The intent of this credit is "To provide an incentive for the achievement of credits that address geographically specific environmental priorities."[202] There were five credit categories that attempted to

[199] (USGBC 2014)
[200] http://www.usgbc.org/node/1732605?return=/credits/new-construction/v2009&view=language
[201] (USGBC n.d.)
[202] http://www.usgbc.org/node/1732600?return=/credits/new-construction/v2009&view=language

fulfill the requirements of this section, out of which four could be satisfied earning the project all four points available.

FINAL SCORE IN CATEGORY

Table 23. Fernow Hall Project LEED certification points for Regional Priority Section[203]

REGIONAL PRIORITY	4 / 4
EAc2 On-site renewable energy	1 / 1
MRc1. 1 Building reuse - maintain existing walls, floors and roof	1 / 1
SSc3 Brownfield redevelopment	1 / 1
SSc6. 1 Storm water design - quantity control	0 / 1
SSc7. 1 Heat island effect – non-roof	1 / 1

FINAL LEEDSCORE:

Table 24. Fernow Hall LEED Certification Points Summary[204]

Category	Earned Points	Possible Points
Sustainable Sites	19	26
Water Efficiency	7	10
Energy / Atmosphere	16	35
Materials / Resources	7	14
Indoor Environmental Quality	8	15
Innovation & Design	5	6
Regional Priority	4	4
TOTAL	66	110

[203] (USGBC 2014)

[204] http://www.sustainablecampus.cornell.edu/initiatives/fernow-hall, 1. Please refer to Appendix N for the complete Score Card.

FERNOW HALL PROJECT CREDITS WITH POSSIBILITY OF USE FOR A HISTORIC STRUCTURE

The following LEED credits used for the Fernow Hall project could be specifically applicable to Historic structures in general.

SSc1 Site Selection

SSc2 Development Density and Community Connectivity

SSc4.1 Alternative Transportation-Public Transportation Access

SSc4.4 Alternative Transportation-Parking Capacity

MRc1.1 Building reuse - maintain existing walls, floors and roof

MRc1.2 Building reuse - maintain interior nonstructural elements

MRc3 Materials reuse

Table 25. Points achieved for LEED Certification of Fernow Hall with possibility of use for a historic structure.

LEED v3 2009 Credit	Intent	Fernow Hall Data	Points
SSc1 Site Selection	Avoid the development of environmentally sensitive lands	Refurbishment of an existing building and the addition is not located on an environmentally sensitive piece of land	1/1
SSc2 Development Density and Community Connectivity	Project site is located within 0. 5 miles of at least 10 community services as well as a residential district with a minimum density of 10 units per acre, which fulfills the requirements of Option 2: Community connectivity	1. Project site is located within 0. 5 miles of at least 10 community services 2. Project site is located within residential district with a minimum density of 10 units per acre	5/5
SSc4.1 Alternative Transportation-Public Transportation Access	Presence of at least 2 bus lines located within 0. 25 miles of the project site fulfills the requirements for Option 2: Bus stop proximity	Presence of at least 2 bus lines located within 0. 25 miles of the project site	6/6

SSc4.4 Alternative Transportation-Parking Capacity	Option 3: Provide no new parking	Provides no new parking	2/2
MRc1.1 Building reuse - maintain existing walls, floors and roof	More than 75% = 2 points	79.60%	2/3
MRc1.2 Building reuse - maintain interior nonstructural elements		Not attempted	0 / 1
MRc3 Materials reuse		Not attempted	0 / 2

4.6. CONCLUSION

As we can see from the above list, there are some credits that might be easier to use in the context of a historic structure. The MRc1.1 credit about building reuse, for example, can get the project up to three points. Many times, historic structures are situated in densely developed areas of the town or city helping to fulfill the credit requirements for surrounding density. Some other credits that might be applicable to other historic structures, such as the MRc1.2 Building reuse - maintain interior nonstructural elements has not been attempted here due to the presence of asbestos.

We have seen that the LEED team, after having fulfilled the minimum mandatory requirements in each category, can choose which other credits to apply for. This could be construed as an example of flexibility of the system but could also be construed as one of the shortcomings. As an example, even though there is s storm water rain garden in the Fernow Hall project, that credit has not been attempted. Then there are many other credits that have not been attempted and there is no information about the reasons for doing so. This gives an incomplete picture of the sustainability issues at the Fernow Hall project.

Another point to consider is how much effect this ‘flexibility’ has on design decisions. If the team has already completed the required credits for a desired rating, would that create an atmosphere

where any additional methods of sustainable design features are discarded as the initial goal of a particular LEED rating has already been achieved and the efforts are just not worth the time and expense? If so, there is a danger of this becoming more an exercise in branding to achieve the chosen rating and less of creating a truly sustainable living environment.

CHAPTER FIVE: ANALYSING THE CASE STUDY DATA – FERNOW HALL, CORNELL UNIVERSITY USING BREEAM AND SKA

5.1. INTRODUCTION

The other Green Building Rating Systems chosen for this analysis are the BREEAM International Refurbishment and Fit-out 2015 (BREEAM International RFO) and the SKA (Offices 1.2). The reason for choosing the new BREEAM scheme is that it being heralded as having credits that will be conducive to Heritage structures, although BREEAM still remains a more comprehensive albeit cumbersome system as compared to the reputation of SKA. SKA is known as being a more adaptable scheme for rehabilitation and fit-out projects. We will use the data collected and calculated for the LEED certification as input for our analysis using BREEAM and SKA.

5.2. BREEAM

Previously, BREEAM for New Construction 2014 was being used for refurbishments and fit-outs in existing buildings, but this study uses the newly launched scheme for further analysis in its application to refurbishment of the historic Fernow Hall building.[205] The analysis was done using the Fernow Hall project data, as was available on the LEED certification online database. This data was compared to the general requirements for the appropriate BREEAM categories and credits. The following table shows the probable points that the Fernow Hall project might have achieved in the BREEAM International Refurbishment and Fit-out 2015. It should be noted that although this analysis was done using data collected and formulated for a different rating system and thus, there are some gaps, there is still sufficient data to carry out a comparison. The same can be said for the analysis for the SKA rating system. (See pages 102-107)

[205] http://www.breeam.org/page.jsp?id=381

Table 26. Probable BREEAM score for Fernow Hall [206]

BREEAM Section	Probable Credits	Credits Available	% of Credits Achieved	Section Weighting (fully fitted)*	% Section Score
Management	14	20	70. 0	0. 12	8. 40
Health and Wellbeing	6	22	27. 3	0. 15	4. 09
Energy	11	34	32. 4	0. 15	4. 85
Transport	9	11	81. 8	0. 09	7. 36
Water	4	9	44. 4	0. 07	3. 11
Materials	4	14	28. 6	0. 135	3. 86
Waste	4	13	30. 8	0. 085	2. 62
Land Use and Ecology	2	5	40. 0	0. 1	4. 00
Pollution	8	13	61. 5	0. 1	6. 15
Innovation	1	10	10. 0	0. 1	1. 00
Final BREEAM score					45. 44
BREEAM Rating					GOOD

As seen earlier, the BREEAM rating has five levels, Pass (30%), Good (45%), Very Good (55%), Excellent (70%) and Outstanding (85%). Even with a conservatively calculated, preliminary analysis and use of data related to a different rating system (LEED v3 2009)[207] and its requirements, the Fernow Hall project achieves the rating of 'Good' for BREEAM International Refurbishment and Fit-out 2015 (BREEAM International RFO).

[206] Please refer to Appendix S for a more detailed analysis. The base data and the BREEAM system taken from the BRE Global webpage. (BRE Global 2014)

[207] For calculating the credits for BREEAM (Ene 01) Reduction of energy use and CO2 emissions, the % of LEED credits awarded was used as benchmark. LEED awarded about 40% of the maximum possible points and so, for BREEAM too, 40% of the maximum possible i.e. 5 out of possible 12 credits were assumed to have been achieved.

5.3. SKA

To recap the SKA working strategy from the Chapter Three 'Green Building Rating Systems', a set of Good Practice Measures (GPM) are selected according to the project parameters. Using these selected GPMs, a preliminary analysis was done using the SKA online assessment tool available on http://ska-tool.rics.org/. Data from the case study LEED documentation was used for this purpose. The initial data input resulted in 104 GPMs to be chosen with 5 GPMs that are not counted in the scope of the work. The following table shows a list of the selected GPMs.

Table 27. GPMs chosen for the Fernow Hall project using SKA rating online assessment tool

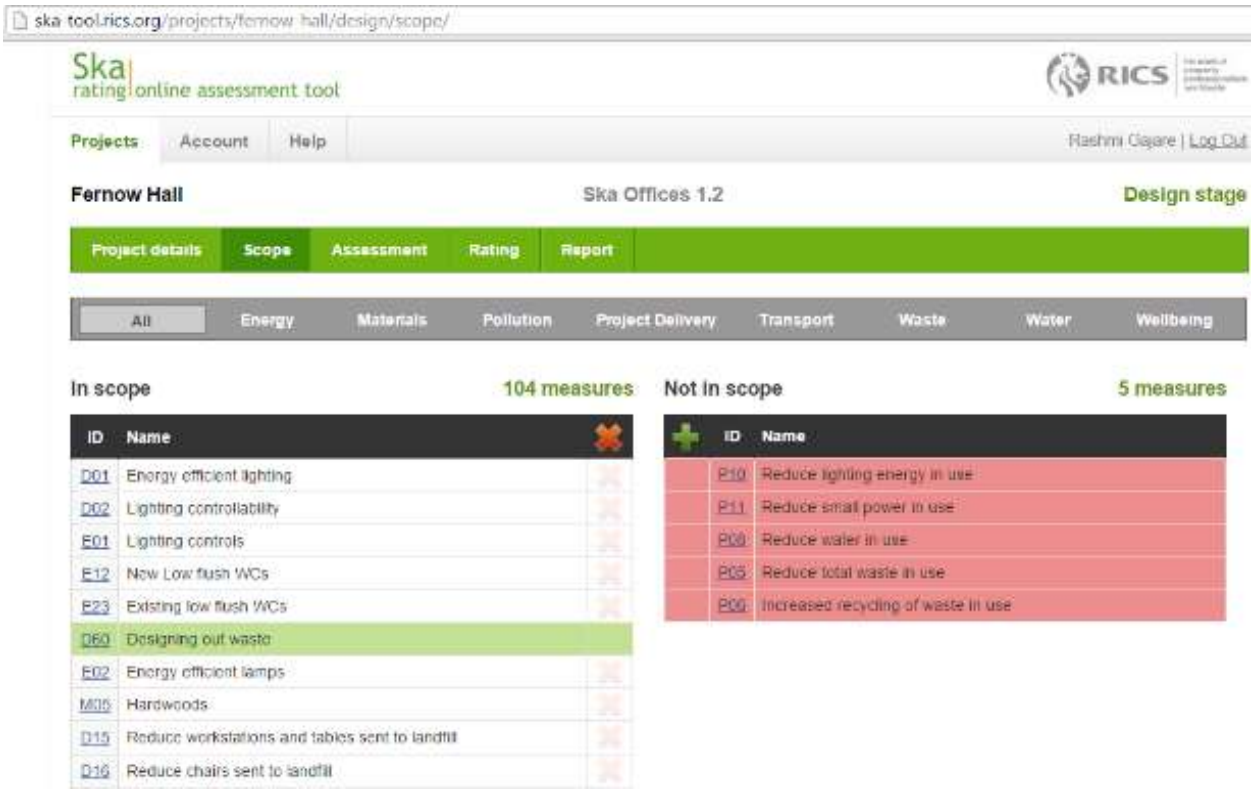


Table (Conti…) GPMs chosen for the Fernow Hall project using SKA rating online assessment tool

D22	Low-GWP insulation	✗
D23	Low-impact refrigerants	✗
D44	CCS registration	
D41	Cycle parking	✗
E05	Energy efficient heat pumps	✗
D28	Thermal comfort assessment	✗
E14	Efficient taps	✗
D20	Timber	✗
D16	Reduce other loose furniture sent to landfill	✗
D17	Reduce storage units sent to landfill	✗
D30	Lighting design	✗
D31	Daylight glare control	✗
D14	Reduce floor finishings sent to landfill	✗
E07	Pipework insulation	✗
E08	Thermal sub-metering	✗
E04	Energy efficient light fittings	✗
E06	HVAC zone controls	✗
D56	Soft landings framework	
D11	Reduce timber sent to landfill	✗
D13	Reduce ceilings sent to landfill	✗
E16	Showers	✗
M07	Raised flooring systems	✗
D12	Reduce partitions sent to landfill	✗

D48	Reduce doors sent to landfill	✗
D10	Reduce masonry sent to landfill	✗
P03	Reduce construction and demolition (C&D) waste sent to landfill	
D33	Ventilation rates	✗
E09	End-use sub metering	✗
D40	CO2 Monitors	✗
E17	Water meter	✗
E22	IT and comms room energy consumption	✗
M01	Blockwork	✗
M10	Suspended ceilings	✗
M06	Partitions	✗
D03	Energy efficient HVAC	✗
D66	Energy modelling	✗
D29	Acoustic design	✗
M12	Soft flooring	✗
D32	Occupant HVAC control	✗
D45	Building User Guide	
D42	Showers	✗
M05	Glazed partitions	✗
M14	Paints	✗
D57	Refrigerant leak prevention	✗
P04	Increase recyled construction and demolition (C&D) waste	
D53	Electrical management	✗

Table (Conti…) GPMs chosen for the Fernow Hall project using SKA rating online assessment tool

D48	Reduce doors sent to landfill	
D10	Reduce masonry sent to landfill	
P03	Reduce construction and demolition (C&D) waste sent to landfill	
D33	Ventilation rates	
E09	End-use sub-metering	
D40	CO2 Monitors	
E17	Water meter	
E22	IT and comms room energy consumption	
M01	Blockwork	
M10	Suspended ceilings	
M08	Partitions	
D03	Energy efficient HVAC	
D66	Energy modelling	
D29	Acoustic design	
M12	Soft flooring	
D32	Occupant HVAC control	
D45	Building User Guide	
D42	Showers	
M09	Glazed partitions	
M14	Paints	
D67	Refrigerant leak prevention	
P04	Increase recycled construction and demolition (C&D) waste	
D63	Electrical management	

Table (Conti…) GPMs chosen for the Fernow Hall project using SKA rating online assessment tool

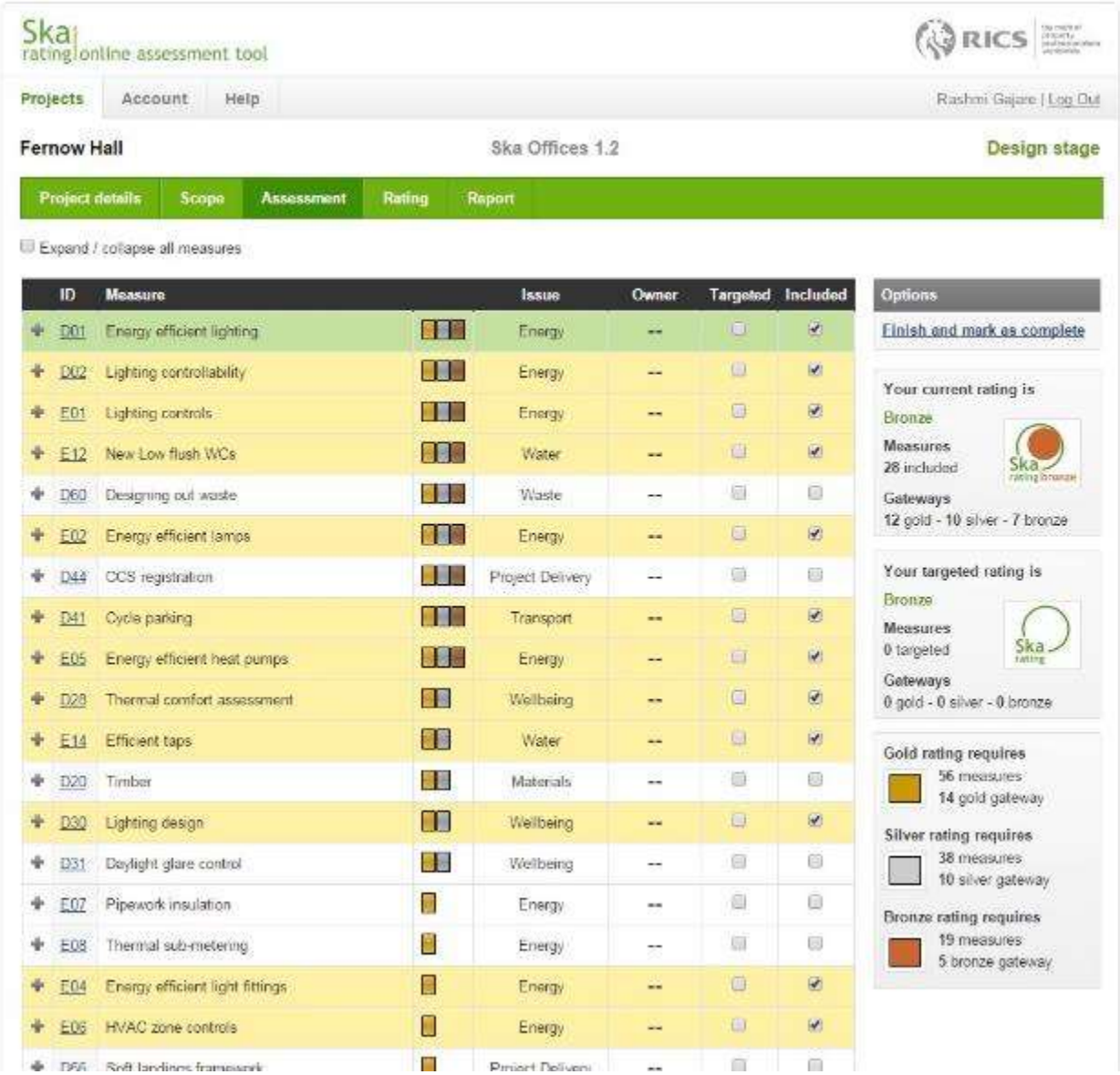
M03	Screed
D36	Cleaning of existing air supply ductwork
P01	Reduce fit-out energy use
D35	Printer copier equipment area ventilation
M21	Storage units
E21	Leakage pressure reducing valve controller
M15	Polishes & varnishes
D37	Fine air filters
M13	Hard wall covering
D59	Construction phase CO2 emissions
P07	Reduce fit-out water use
D43	Cyclist lockers
D62	Staff breakout space
M23	Window treatments
D39	Outside views
M24	Paper and towel dispensers
D26	Reduce light pollution
M16	Wall covering
D21	Total recycled materials
D27	Refrigerant recovery
D19	Materials specification
P09	Display Energy Certificates (DECs)
D25	Limiting plant noise
D68	NOx emissions
D64	VOC monitors
P12	Fit-out VOC monitoring

Since the interior furnishings and furniture at Fernow Hall had to be discarded due to asbestos remediation process, many of the GPMs suggested by the online software, such as #12 Reduce workstations and tables sent to landfill and Lockers (Waste) and #26 Reduce floor finishings sent to landfill (Waste) were removed manually, thus reducing the number of GPMs to 75.

The issues regarding refrigerant use and management, also, cannot be analyzed as Lake Source cooling was used and so they are not included in the list of project relevant measures.

Additionally, there is not enough information to analyze for issues such as # 85 (Well-being) ‘Cleaning of existing air supply ductwork’, but which might have been undertaken to fulfill the basic IAQ Prerequisite.

Table 28. Probable score for Fernow Hall project using SKA rating system



Ska rating online assessment tool

RICS

Projects | Account | Help | Rashmi Gajare | Log Out

Fernow Hall | Ska Offices 1.2 | Design stage

Project details | Scope | Assessment | Rating | Report

Expand / collapse all measures

ID	Measure	Issue	Owner	Targeted	Included
D01	Energy efficient lighting	Energy	--	☐	☑
D02	Lighting controllability	Energy	--	☐	☑
E01	Lighting controls	Energy	--	☐	☑
E12	New Low flush WCs	Water	--	☐	☑
D60	Designing out waste	Waste	--	☐	☐
E02	Energy efficient lamps	Energy	--	☐	☑
D44	CCS registration	Project Delivery	--	☐	☐
D41	Cycle parking	Transport	--	☐	☑
E05	Energy efficient heat pumps	Energy	--	☐	☑
D28	Thermal comfort assessment	Wellbeing	--	☐	☑
E14	Efficient taps	Water	--	☐	☑
D20	Timber	Materials	--	☐	☐
D30	Lighting design	Wellbeing	--	☐	☑
D31	Daylight glare control	Wellbeing	--	☐	☐
E07	Pipework insulation	Energy	--	☐	☐
E08	Thermal sub-metering	Energy	--	☐	☐
E04	Energy efficient light fittings	Energy	--	☐	☑
E06	HVAC zone controls	Energy	--	☐	☑
D66	Soft landings framework	Project Delivery	--	☐	☐

Options

Finish and mark as complete

Your current rating is
Bronze
Measures
28 included
Gateways
12 gold - 10 silver - 7 bronze

Your targeted rating is
Bronze
Measures
0 targeted
Gateways
0 gold - 0 silver - 0 bronze

Gold rating requires
56 measures
14 gold gateway

Silver rating requires
38 measures
10 silver gateway

Bronze rating requires
19 measures
5 bronze gateway

The online preliminary assessment obtained a Bronze rating for the project. This would likely progress towards a Silver rating if more information could be obtained. If there were measures taken to reduce daylight glare, for example, the completion of GMP D31 Daylight Control Glare would add a Silver rating point to the tally. If the GMP D36 Cleaning of existing air supply ductwork was completed, that would add to the overall score.

5.4. CONCLUSION

As we can see from the results above, the BREEAM scheme has resulted in a 'Good' rating (more than 45%) credits whereas the SKA scheme has yielded a 'Bronze' rating, its lowest. This contrast might be due to non-availability of appropriate data but could also be an indication of its stricter standards. Another reason for this disparity could be that SKA is a scheme for interior refurbishment and thus apart from a few credits like Cycle parking, does not award points for site location actions. BREEAM awards points for the site location. SKA, nevertheless, appears to be flexible as to the scope of work according to the parameters of diverse projects and thus could be a useful tool in the 'greening' of historic structures.

More focused data collection and calculation as well as more in-depth data analysis, the same project details might lead to a higher rating achievement in both the systems. The analysis, in effect, points out the differences in the data requirements for the various schemes. A more standardized grammar for green building certification might be the next step towards better competition between the various schemes on offer.

CONCLUSION

This thesis started with a study of various definitions of Sustainability and an examination of many of the indicators used to by various organizations and governments to quantify it. The concept of the 3 Rs - Reuse, Reduce and Recycle - was discussed. One of the quantification methods for sustainability was the application of sustainability principles to the building industry. Many sustainability indicators, discussed in an earlier chapter, find a place in the basic framework of the green-building rating systems. This report further discussed a few of these green-building rating systems and analyzed the Fernow Hall project within the parameters set by three of them. This analysis has led to interesting observations, although none that were surprising.

We found during our analysis of the case study that not all the credits were attempted. This could be due to reasons such as lack of relevant data or the difficulty in obtaining it. It could also be a reflection of the attempt to fulfill only the minimum requirements for the rating level chosen according to the priorities of the construction company. After all, for a layperson such as a customer of the construction company, it is possible that having any LEED certified rating could be important rather than specifically a 'Silver' or 'Gold' rating. It is the LEED brand that would make the desired impression. On the other hand, informed and conscious customers might insist on higher ratings if they reflect increased energy-cost savings.

Another observation was the marked difference between the outcomes of using the data from the same case study for the different green-building rating systems. The LEED v3 resulted in a 'Gold' rating ranked third out of its possible four rating levels. BREEAM gave a 'Good' rating, second out its five rating levels and SKA, a 'Bronze', its lowest level. This could be, on one hand, due to the difference in the basic goals of the rating systems. But, on the other hand, it could just be the difference in the languages used. With more focused data collection and calculation as well as more in-depth data analysis, the same project details might lead to a higher rating achievement in both the systems. The

analysis, in effect, points out the differences in the data requirements for the various schemes. A more standardized grammar for green-building certification might be the next step towards better competition between the various schemes on offer.

As far as an analysis of the applicability of the varied systems to a Historic Structure, in the absence of comprehensive and appropriate data for the different systems, a credible conclusion is not possible at this moment. It is a case of trying to fit the 'octagon' of historic structures into the 'square' peg of existing green-building rating systems that have been designed fundamentally for new construction, Thus, a rating system that is *specifically aimed* at helping historic structure rehabilitation projects to incorporate sustainable building measures might be a goal. As the construction industry matures in burgeoning centers of development, the amount of existing building stock is going to, in all probability, increase. Although not all modern buildings, or for that matter older buildings could be deemed 'Historic', it is an undeniable fact that every day, more buildings are included under the umbrella of Historic Structures. Thus a green-building rating system with a specific focus on historic-building sustainability is the need of the hour. It should have the flexibility that is evident in systems such as SKA and now, to some extent BREEAM and LEED, and should be sensitive to the needs of protecting the historic fabric and integrity of the structures. With the inclusion of the new quantification methods such as energy and water metering for LEED v4, more accurate data would be available to better understand the relationship between modern, electrical and mechanical systems and historic structures. This should be used as a tool while creating the unique green-building rating system for historic structures.

As has been discovered though the discussions in this paper, flexibility could be one of the highly desired features when proposing a rating system for Historic Structures, be it in choosing the applicable criteria (as seen in SKA or with the new BREEAM scheme) or in application of those criteria (as seen in the option of using high VOC finishes if deemed essential by a qualified body).

The next desirable quality is the inclusion of more actions that are focused on the specific case of Historic Structures. The new BREEAM International Refurbishment and Fit-out 2015, as has been

explained in the chapter on green-building rating systems, has many features that promote better applicability for historic structures with an emphasis on safeguarding the historic building fabric while incorporating environmentally friendly systems. In fact, if proven to harm the building due to conservation issues, the credits are awarded even for non-compliance to the requirements of that credit.[208] Moreover, the qualitative benefits of Historic Preservation to a society have to be given their due credit. Interestingly enough, although GRIHA, the green-building rating system from India does not have a scheme for existing buildings, it includes the assessment of 'Qualitative' effects of actions in its calculations. It has its heart at the right place but needs to expand its purview to Historic Structures.

The historic status of a structure is, inherently, a qualitative construct of the times and the society in which it exists at present. In addition to the importance of safeguarding our irreplaceable heritage, if the quantitative benefits to the environment of reusing an existing structure rather than replacing it with a new building could be better elucidated and compared, the demand for a distinct rating system for Historic Structures might gain more gravitas. To do this, better and more comprehensive data collection could prove of some help. After all, the importance of energy savings by using modern, environmentally-friendly HVAC and electrical systems, a well-documented phenomenon, might be comparable to the energy saved by the building orientation and basic space configuration. Historic Structures that were built before the proliferation of modern technological systems in air conditioning might have considered passive methods of enhancing human comfort thus saving energy inherently, by their design. A study done by Preservation Green Lab[209] in 2011 compared existing and new buildings of comparable parameters, concluding that it is almost always better to reuse an existing building than not. The study also reiterates the point mentioned here earlier that better data collection is imperative to a better understanding of the various process involved. This seems to reflect in some of the new versions of the existing green-building systems. The latest LEED v4 system makes energy and water use metering

[208] (BREEAM 2015), 125.
[209] (Preservation Green Lab 2011)

mandatory. This will provide data to better understand the true impact of the existing measures and help in improving the systems in the future.

It is evident that green-building rating systems are undergoing major changes at the moment, a welcome event with the specter of climate change looming closer by the day. The realization that reusing existing building stock is a sensible approach towards safeguarding the environment is not an argument that needs a debate anymore. It is the 'how to proceed now' that needs more discussion as well as inclusion of more diverse stakeholders. The green-building rating movement has historically been thought to have been led by industry as a means to propagate its products, although over time, the systems seem to have 'evolved' from being product-use centric to being more focused on the system performance. The next step should be to incorporate integral concepts of Historic Preservation to propose a distinct system for Historic Structures. In the end, both the movements of Sustainability and Historic Preservation are about protecting the 'present' for the 'future', two sides of the same coin.

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APPENDIX A

Report of the United Nations Conference on Environment and Development, Rio de Janeiro, 3-14 June 1992

United Nations

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REPORT OF THE UNITED NATIONS CONFERENCE ON

ENVIRONMENT AND DEVELOPMENT*

(Rio de Janeiro, 3-14 June 1992)

Annex I

RIO DECLARATION ON ENVIRONMENT AND DEVELOPMENT

The United Nations Conference on Environment and Development,

Having met at Rio de Janeiro from 3 to 14 June 1992,

Reaffirming the Declaration of the United Nations Conference on the Human Environment, adopted at Stockholm on 16 June 1972, a/ and seeking to build upon it,

With the goal of establishing a new and equitable global partnership through the creation of new levels of cooperation among States, key sectors of societies and people,

Working towards international agreements which respect the interests of all and protect the integrity of the global environmental and developmental system,

Recognizing the integral and interdependent nature of the Earth, our home,

Proclaims that:

Principle 1

Human beings are at the centre of concerns for sustainable development. They are entitled to a healthy and productive life in harmony with nature.

Principle 2

States have, in accordance with the Charter of the United Nations and the principles of international law, the sovereign right to exploit their own resources pursuant to their own environmental and developmental policies, and the responsibility to ensure that activities within their jurisdiction or control do not cause damage to the environment of other States or of areas beyond the limits of national jurisdiction.

Principle 3

The right to development must be fulfilled so as to equitably meet developmental and environmental needs of present and future generations.

Principle 4

In order to achieve sustainable development, environmental protection shall constitute an integral part of the development process and cannot be considered in isolation from it.

Principle 5

All States and all people shall cooperate in the essential task of eradicating poverty as an indispensable requirement for sustainable development, in order to decrease the disparities in standards of living and better meet the needs of the majority of the people of the world.

Principle 6

The special situation and needs of developing countries, particularly the least developed and those most environmentally vulnerable, shall be given special priority. International actions in the field of environment and development should also address the interests and needs of all countries.

Principle 7

States shall cooperate in a spirit of global partnership to conserve, protect and restore the health and integrity of the Earth's ecosystem. In view of the different contributions to global environmental degradation, States have

common but differentiated responsibilities. The developed countries acknowledge the responsibility that they bear in the international pursuit of sustainable development in view of the pressures their societies place on the global environment and of the technologies and financial resources they command.

Principle 8

To achieve sustainable development and a higher quality of life for all people, States should reduce and eliminate unsustainable patterns of production and consumption and promote appropriate demographic policies.

Principle 9

States should cooperate to strengthen endogenous capacity-building for sustainable development by improving scientific understanding through exchanges of scientific and technological knowledge, and by enhancing the development, adaptation, diffusion and transfer of technologies, including new and innovative technologies.

Principle 10

Environmental issues are best handled with the participation of all concerned citizens, at the relevant level. At the national level, each individual shall have appropriate access to information concerning the environment that is held by public authorities, including information on hazardous materials and activities in their communities, and the opportunity to participate in decision-making processes. States shall facilitate and encourage public awareness and participation by making information widely available. Effective access to judicial and administrative proceedings, including redress and remedy, shall be provided.

Principle 11

States shall enact effective environmental legislation. Environmental standards, management objectives and priorities should reflect the environmental and developmental context to which they apply. Standards applied by some countries may be inappropriate and of unwarranted economic and social cost to other countries, in particular developing countries.

Principle 12

States should cooperate to promote a supportive and open international economic system that would lead to economic growth and sustainable development in all countries, to better address the problems of environmental degradation.
Trade policy measures for environmental purposes should not constitute a means of arbitrary or unjustifiable discrimination or a disguised restriction on international trade. Unilateral actions to deal with environmental challenges outside the jurisdiction of the importing country should be avoided.
Environmental measures addressing transboundary or global environmental problems should, as far as possible, be based on an international consensus.

Principle 13

States shall develop national law regarding liability and compensation for the victims of pollution and other environmental damage. States shall also cooperate in an expeditious and more determined manner to develop further international law regarding liability and compensation for adverse effects of environmental damage caused by activities within their jurisdiction or control to areas beyond their jurisdiction.

Principle 14

States should effectively cooperate to discourage or prevent the relocation and transfer to other States of any activities and substances that cause severe environmental degradation or are found to be harmful to human health.

Principle 15

In order to protect the environment, the precautionary approach shall be widely applied by States according to their capabilities. Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation.

Principle 16

National authorities should endeavour to promote the internalization of environmental costs and the use of economic instruments, taking into account the approach that the polluter should, in principle, bear the cost of pollution, with due regard to the public interest and without distorting international trade and investment.

Principle 17

Environmental impact assessment, as a national instrument, shall be undertaken for proposed activities that are likely to have a significant adverse impact on the environment and are subject to a decision of a competent national authority.

Principle 18

States shall immediately notify other States of any natural disasters or other emergencies that are likely to produce sudden harmful effects on the environment of those States. Every effort shall be made by the international community to help States so afflicted.

Principle 19

States shall provide prior and timely notification and relevant information to potentially affected States on activities that may have a significant adverse transboundary environmental effect and shall consult with those States at an early stage and in good faith.

Principle 20

Women have a vital role in environmental management and development. Their full participation is therefore essential to achieve sustainable development.

Principle 21

The creativity, ideals and courage of the youth of the world should be mobilized to forge a global partnership in order to achieve sustainable development and ensure a better future for all.

Principle 22

Indigenous people and their communities and other local communities have a vital role in environmental management and development because of their knowledge and traditional practices. States should recognize and duly support their identity, culture and interests and enable their effective participation in the achievement of sustainable development.

Principle 23

The environment and natural resources of people under oppression, domination and occupation shall be protected.

Principle 24

Warfare is inherently destructive of sustainable development. States shall therefore respect international law providing protection for the environment in times of armed conflict and cooperate in its further development, as necessary.

Principle 25

Peace, development and environmental protection are interdependent and indivisible.

Principle 26

States shall resolve all their environmental disputes peacefully and by appropriate means in accordance with the Charter of the United Nations.

Principle 27

States and people shall cooperate in good faith and in a spirit of partnership in the fulfilment of the principles embodied in this Declaration and in the further development of international law in the field of sustainable development.

* * * * *

a/ Report of the United Nations Conference on the Human Environment, Stockholm, 5-16 June 1972 (United Nations publication, Sales No. E.73.II.A.14 and corrigendum), chap. I.

APPENDIX B

Sustainability INDICATORS, Sustainable development in the European Union

(The list of indicators chosen to be presented here is as per the author's perceived relevance to the topic under discussion)

tsdec100 Growth rate of GDP per inhabitant GDP growth per capita CH1: 46, 47 (SI), (MDG), (UN-CSD), (Laeken), (OECD)

Economic development

tsdec210 Total investment Investment CH1: 49 (UN-CSD), (OECD)
tsdec211 Public investment Investment CH1: 49
tsdec212 Business investment Investment CH1: 49 SI
tsdec220 Dispersion of regional GDP per inhabitant Regional disparities in GDP CH1: 51 (OECD)
tsdec230 Net national income
tsdec240 Household saving rate Household saving CH1: 52 (UN-CSD), (OECD)

Innovation, competitiveness and eco-efficiency

tsdec310 Growth rate of labour productivity per hour worked, Labour productivity growth CH1: 53 (SI), (UN-CSD), (OECD)
tsdec320 Total R&D expenditure R&D expenditure CH1: 54 SI, (UN-CSD), (OECD)
tsdec330 Real effective exchange rate
tsdec340 Turnover from innovation
tsdec350 Effects of innovation on material and energy efficiency
tsien020 Energy intensity of the economy Energy intensity CH1: 55 SI, (UN-CSD), (EEA), (OECD)
tsdec370 Effects of innovation on reduced environmental impacts or improved health and safety

Employment

tsdec410 Employment rate Employment CH1: 56 (SI), (MDG), (UN-CSD), (Laeken), (OECD)
tsdec420 Employment rate, by gender Female employment CH1: 58 SI, (Laeken), (OECD)
tsdec430 Employment rate, by highest level of education attained Employment CH1: 57 (OECD)
tsdec440 Dispersion of regional employment rates, by gender disparities in regional employment CH1: 59 SI, (Laeken), (OECD)
tsdec450 Unemployment rate, by gender Unemployment CH1: 62 SI, (Laeken), (OECD)
tsdec460 Unemployment rate, by age group Unemployment CH1: 62 (Laeken)

Indicators to be developed

Genuine savings; Eco-innovations

Sustainable consumption and production

Resource use and waste

tsdpc100 Resource productivity Resource productivity CH4: 124,125 SI, (UN-CSD)
tsdpc210 Municipal waste generated Municipal waste CH4: 129 SI, (UN-CSD), (EEA), (OECD)
tsdpc220 Components of domestic material consumption domestic material consumption CH4: 127
tsdpc230 Domestic material consumption by material Domestic material consumption CH4: 128 (UN-CSD)
tsdpc240 Municipal waste treatment, by type of treatment method recycled and composted municipal waste CH4: 130 SI, (UN-CSD), (EEA)
tsdpc250 *Generation of hazardous waste, by economic activity** (UN-CSD)

Atmospheric emissions

tsdpc260 Emissions of acidifying substances by source sector CH4: 131, 132 (EEA)
tsdpc270 Emissions of ozone precursors by source sector Atmospheric emissions CH4: 131, 132 (EEA)
tsdpc280 Emissions of particulate matter by source sector atmospheric emissions CH4: 131, 132 (EEA)

Consumption patterns

tsdpc310 Electricity consumption of households Electricity consumption of households CH4: 136
tsdpc320 Final energy consumption, by sector Final energy consumption CH4: 137 (UN-CSD), (EEA)
tsdpc330 Consumption of certain foodstuffs per inhabitant
tsdpc340 Motorisation rate Car ownership CH4: 138

Production patterns

tsdpc410 Organisations and sites with EMAS registration, Environmental management systems CH4: 139
tsdpc420 Eco-label awards Eco-labels CH4: 140
tsdpc430 Area under agri-environmental commitment (SEBI)
tsdpc440 Area under organic farming Organic farming CH4: 142 (UN-CSD), (EEA)
tsdpc450 Livestock density index Livestock density index CH4: 143

Contextual indicators

tsdpc510 Number of households (for sub-theme Consumption patterns) Number of households CH4: 134
tsdpc520 Household expenditure per inhabitant, by category (for sub-theme Consumption patterns) Household expenditure CH4: 135 (OECD)

Indicators to be developed

Total material consumption; Green public procurement ;Share of consumption of products with an ecolabel / Awareness of ecolabels Nitrogen balance (SEBI); Ethical financing

Share of industrial production from enterprises with a formal environmental management system; Share of production of products with an ecolabel; Energy and material use per unit of output, by industrial sector

Social inclusion

Monetary poverty and living conditions

tsdsc100 At-risk-of-poverty rate, by gender Risk of poverty CH7: 200, 202 SI, (UN-CSD), (Laeken), (OECD)

tsdsc210 *At-persistent-risk-of-poverty rate* SI, (Laeken)*

tsdsc230 At-risk-of-poverty rate, by age group Risk of poverty CH7: 200, 201

tsdsc240 At-risk-of-poverty rate, by household type Risk of poverty CH7: 201

tsdsc250 Relative at-risk-of-poverty gap Intensity of poverty CH7: 203 (MDG), Laeken, (OECD)

tsdsc260 Inequality of income distribution Income inequalities CH7: 204 SI, (UN-CSD), (Laeken), (OECD)

Access to labour market

tsdsc310 People living in jobless households, by age group Jobless households CH7: 205 (SI), Laeken

tsdsc320 In-work poverty Working poor CH7: 206 (Laeken)

tsdsc330 Total long-term unemployment rate Long-term unemployment CH7: 207 SI, (Laeken), (OECD)

tsdsc340 Unadjusted gender pay gap Gender pay gap CH7: 208 SI

Education

tsdsc410 Early school-leavers Early school-leavers CH7: 210 SI, Laeken

tsdsc420 At-risk-of-poverty rate, by highest level of education attained Risk of poverty CH7: 201

tsdsc430 Persons with low educational attainment, by age group Adults with low educational attainment (adults) CH7: 211 (SI), (UN-CSD), Laeken, (OECD)

tsdsc440 Life-long learning Lifelong learning CH7: 212 SI, (UN-CSD)

tsdsc450 Low reading literacy performance of pupils Laeken

tsdsc460 Individuals' level of computer skills

tsdsc470 Individuals' level of internet skills

Contextual indicator

tsdsc510 Public expenditure on education (for subtheme Education) Public expenditure on education CH7: 209 SI, (OECD)

Indicators to be developed

Child well-being (Laeken); Material deprivation (Laeken);Adequacy of housing conditions (Laeken)

Demographic changes

Demography

tsdde100 Employment rate of older workers Employment rate of older workers CH8: 221 SI, Laeken, (OECD)

tsdde210 Life expectancy at age 65, by gender Life expectancy at age 65 CH8: 223 (Laeken)
tsdde220 Total fertility rate Fertility rate CH8: 224 (UN-CSD), (OECD)
tsdde230 Crude rate of net migration Migration CH8: 225 (OECD)

Old-age income adequacy
tsdde310 Aggregate replacement ratio Income level of over-65s compared to before CH8: 227 Laeken
tsdde320 At-risk-of-poverty rate of elderly people Risk of poverty for over-65s CH8: 228 (Laeken)

Public finance sustainability
tsdde410 General government debt Public debt CH8: 229 SI, (UN-CSD), (Laeken),(OECD)
tsdde420 Average exit age from the labour market Retirement age CH8: 230 SI, (Laeken)

Contextual indicators
tsdde510 Old-age-dependency ratio (for sub-theme Demographic changes)Elderly population compared to working age population CH8: 226 (UN-CSD), (Laeken), (OECD)
tsdde511 Projected old-age dependency ratio (for subtheme Demographic changes) Elderly population compared to working age population CH8: 226 (Laeken)
tsdde520 Projected evolution of EU-27 age-related public spending – baseline scenario (for subtheme Public finance sustainability) The impact of ageing on public expenditure CH8: 232 (Laeken), (OECD)
tsdde521 Projected evolution of theoretical income replacement ratios (for sub-theme Public finance sustainability) The impact of ageing on public expenditure CH8: 233
tsdde530 Expenditure on care for the elderly (for subtheme Public finance sustainability) Expenditure on care for the elderly CH8: 231 (Laeken)
Indicators to be developed
Health expenditure on old age (Laeken)

Public health
Health and health inequalities
tsdph100 Healthy life years and life expectancy at birth,by gender Healthy life years CH6: 177 SI, (UN-CSD), (Laeken),(OECD)
tsdph210 Death rate due to chronic diseases, by gender Deaths due to chronic diseases CH6: 179
tsdph220 Healthy life years and life expectancy at age 65, by gender Healthy life years CH6: 177
tsdph240 Suicide death rate, by age group Suicides CH6: 180 (UN-CSD), (OECD)
tsdph250 Suicide death rate, males by age group Suicides
tsdph260 Suicide death rate, females by age group Suicides
tsdph270 Self reported unmet need for medical examination or treatment, by income quintile Unmet needs for healthcare CH6: 182 (Laeken), (OECD)
*Dispersion of regional death rates**

Determinants of health

tsdph320	Index of production of toxic chemicals, by toxicity class Production of toxic chemicals CH6: 183
tsdph370	Population exposure to air pollution by particulate matter Exposure to air pollution by particulate matter CH6: 185, 186 SI, (UN-CSD), (EEA)
tsdph380	Population exposure to air pollution by ozone Exposure to air pollution by ozone CH6: 187 SI, (UN-CSD), (EEA)
tsdph390	Population living in households considering that they suffer from noise Annoyance by noise CH6: 189, 190
tsdph400	Serious accident at work Serious accidents at work CH6: 191 SI

Indicators to be developed

Incidence of chronic diseases; Childhood health/diseases; Deaths due to infectious food-borne diseases; Index of apparent consumption of chemicals by toxicity class; Dioxins and PCBs in food and feed; Pesticide residues in food; Overweight people, by age group (Laeken), (OECD) Present smokers, by gender and by age group (UN-CSD), (Laeken); Work with a high level of job strain/stress; Monetary damage of air pollution as % of GDP

Climate change and Energy

Climate change

tsdcc100	Greenhouse gas emissions Greenhouse gas emissions CH2: 73, 74 SI, (UN-CSD), (EEA)
tsdcc110	Share of renewables in gross inland energy consumption; Consumption of renewables CH2: 76, 77 (UN-CSD), (EEA), (OECD)
tsdcc210	Greenhouse gas emissions by sector Greenhouse gas emissions by sector CH2: 79, 80
tsdcc220	Greenhouse gas emissions intensity of energy consumption Greenhouse gas intensity of energy consumption CH2: 81 (OECD); Projections of greenhouse gas emissions Greenhouse gas emissions CH2: 73 EEA; Global surface average temperature Global surface average temperature CH2: 82 EEA

Energy

tsdcc310	Energy dependency Energy dependency CH2: 83
tsdcc320	Gross inland energy consumption, by fuel Gross inland energy consumption CH2: 84 (EEA), (OECD)
tsdcc330	Electricity generated from renewable sources Electricity generation from renewable sources; CH2: 85 SI, (EEA), (OECD)
tsdcc340	Share of biofuels in fuel consumption of transport; Consumption of biofuels in transport CH2: 86 (EEA)
tsdcc350	Combined heat and power generation Combined heat and power CH2: 87 SI
tsdcc360	Implicit tax rate on energy Implicit tax rate on energy CH2: 88 SI

Indicators to be developed

Radioactive waste (UN-CSD); External costs of energy use

Sustainable transport

Transport and mobility

tsdtr100 Energy consumption of transport; Energy consumption of transport relative to GDP; CH3: 98-100 (UN-CSD)

tsdtr210 Modal split of passenger transport Modal split of passenger transport CH3: 103 (SI), (UN-CSD)

tsdtr220 Modal split of freight transport Modal split of freight transport CH3: 101 (SI), (UN-CSD)

tsdtr230 Volume of freight transport; Volume of freight transport relative to GDP CH3: 105 SI, (EEA)

tsdtr240 Volume of passenger transport; Volume of passenger transport relative to GDP CH3: 106 SI, (EEA);Modal share of investment in transport infrastructure Investment in transport infrastructure; CH3: 107

Transport impacts

tsdtr410 Greenhouse gas emissions by transport mode; Greenhouse gas emissions from transport CH3: 111

tsdtr420 People killed in road accidents People killed in road accidents CH3: 110 (OECD)

tsdtr430 Emissions of ozone precursors from transport Emissions of ozone precursors from transport CH3: 114

tsdtr440 Emissions of particulate matter from transport; Emissions of particulate matter from transport CH3: 115

tsdtr450 Average CO2 emissions per km from new passenger cars Average CO2 emissions per km from new passenger cars CH3: 113

Contextual indicator

tsdtr310 Price indices for transport (for sub-themeTransport and mobility) Passenger transport prices CH3: 109

Indicators to be developed

Vehicle-km by road; Use of public transport;External costs of transport activities; Fragmentation of natural and semi-natural areas (to appear either in this theme or in natural resources, depending on the type of indicator that is developed) (SEBI), (UN-CSD)

Natural resources

Biodiversity

tsdnr100 Common bird index Abundance of common birds CH5: 155 (SI), (SEBI), (UN-CSD)

tsdnr110 Fish catches taken from stocks outside safe biological limits Conservation of fish stocks CH5: 156 SI, (MDG), (UN-CSD), (EEA)

tsdnr210 Sufficiency of sites designated under the EU Habitats Directive Protected areas CH5: 158 SI, SEBI, (MDG), (UNCSD), (EEA)

tsdnr220 Deadwood on forest land Deadwood on forest land CH5: 160 (SEBI)

Freshwater resources

tsdnr310 Surface and groundwater abstraction as a share of available resources Water abstraction CH5: 161, 162 (MDG), (UN-CSD), (EEA), (OECD)

tsdnr320 Population connected to urban wastewater treatment with at least secondary treatment Wastewater treatment (EEA) Biochemical oxygen demand in rivers Water quality in rivers CH5: 163 (SEBI), (UN-CSD), (EEA)

Marine ecosystems

tsdnr410 *Concentration of mercury in fish and shellfish**

tsdnr420 Size of fishing fleet Fishing capacity CH5: 164 (EEA), (OECD)

Land use

tsdnr510 Built-up areas Change in land cover CH5: 165, 166 (UN-CSD), (EEA)

tsdnr520 Forest increment and fellings (SEBI)

tsdnr530 Forest trees damaged by defoliation Forest trees damaged by defoliation CH5: 167 (UN-CSD)

tsdnr540 *Percentage of total land area at risk of soil erosion** (UN-CSD)

Indicators to be developed

Biodiversity Index; Abundance and distribution of selected species SEBI, (EEA); Change in status of species of European interest - Red List Index for European species SEBI, (MDG), (UN-CSD), (EEA); Index of toxic chemical risk to aquatic environment / Percentage of water bodies with high or good ecological status (UN-CSD); Concentration of organic matter as chemical oxygen demand of rivers; Effective fishing capacity and quotas; Structural support to fisheries and % allocated to promote environmentally friendly fishing practices (OECD); Seagrasses Critical load exceedance for nitrogen SEBI

Global partnership

Globalisation of trade

tsdgp100 Official development assistance as share of gross national income Official development assistance CH9: 243 (MDG), (UN-CSD), (OECD)

tsdgp210 EU Imports from developing countries, by income group Imports from developing countries CH9: 245 (MDG), (UN-CSD)

tsdgp220 EU Imports from developing countries, by group of products (MDG), (UN-CSD)

tsdgp230 EU Imports from least-developed countries, by group of products Share of imports from least-developed countries CH9: 246 (MDG), (UN-CSD)

tsdgp240 Aggregated measurement of support for agriculture Subsidies for EU agriculture CH9: 247 (MDG), (OECD)

Financing for sustainable development

tsdgp310 Total EU financing for developing countries, by type Financing for developing countries CH9: 248

tsdgp320 Foreign direct investment in developing countries, by income group Share of foreign direct investment in low-income countries CH9: 249 (SI), (UN-CSD), (OECD)

tsdgp330 Official development assistance, by income group Share of official development assistance for low-income countries CH9: 250

tsdgp340 Untied official development assistance Share of untied assistance CH9: 251 (MDG)

tsdgp350 Bilateral official development assistance dedicated to debt Assistance for debt relief CH9: 252 (OECD)
tsdgp350 Bilateral official development assistance dedicated to social services Assistance for social infrastructure and services CH9: 253 (MDG), (OECD)

Global resources management
tsdgp410 CO2 emissions per inhabitant in the EU and in developing countries CO2 emissions per inhabitant CH9: 254 (MDG)
tsdgp350 Bilateral official development assistance dedicated to water supply and sanitation Assistance for water supply and sanitation CH9: 255 (OECD)
Contextual indicators
tsdgp510 *Population living on less than 1USD a day (for sub-theme Financing for sustainable development)** (MDG), (UN-CSD)
tsdgp520 Official development assistance per capita in donor and recipient countries (for sub-theme Financing for SD) Official development assistance CH9: 244
tsdgp530 *Population with sustainable access to an improved water source (for sub-theme global resource management)** (MDG), (UN-CSD)

Indicators to be developed
Sales of selected fair-trade-labelled products; Share of global greenhouse gas emissions from countries having agreed limits on their emissions; Contribution of the Clean Development Mechanism to greenhouse gas emission reductions in developing countries; Global footprint
Good governance

Policy coherence and effectiveness
tsdgo210 New infringement cases, by policy area Infringement cases CH10: 265
tsdgo220 Transposition of Community law by policy area; Transposition of Community law CH10: 267

Openness and participation
tsdgo310 Voter turnout in national and EU parliamentary elections Voter turnout CH10: 269
tsdgo320 E-government on-line availability E-government availability CH10: 271 SI
tsdgo330 E-government usage by individuals E-government usage CH10: 272 SI

Economic instruments
tsdgo410 Shares of environmental and labour taxes in total tax revenues Environmental taxes compared to labour taxes CH10: 274
Contextual indicator
tsdgo510 Level of citizens' confidence in EU institutions (for sub-theme Policy coherence and effectiveness) Citizens' confidence in EU institutions CH10: 264
Indicators to be developed
Administrative cost imposed by legislation; Impact assessment; Openness and participation; Level of involvement of consumer groups and companies; Public consultations; Proportion of environmentally harmful subsidies

APPENDIX C

BREEAM score and rating calculation

Table - 5: Example BREEAM score and rating calculation

BREEAM Section	Credits Achieved	Credits Available*	% of Credits Achieved	Section Weighting*	Section score
Management	10	22	45.00%	0.12	5.45
Health & wellbeing	8	10	80.00%	0.15	12
Energy	16	30	53.33%	0.19	10.13%
Transport	5	9	55.56%	0.08	4.44%
Water	5	9	55.56%	0.06	3.33%
Materials	6	12	50.00%	0.125	6.25%
Waste	3	7	42.86%	0.075	3.21%
Land use & Ecology	5	10	50.00%	0.10	5.00%
Pollution	5	13	38.50%	0.10	3.85%
Innovation	2	10	20.00%	0.10	2.00%
Final BREEAM score					55.66%
BREEAM rating					VERY GOOD

*This will vary depending on building type and location
Source:

http://www.breeam.org/BREEAMInt2013SchemeDocument/content/03_scoringrating/scoring.htm#BREEAM_rating_benchmarks

Table - 6: Minimum standards for BREEAM ‘Very Good’ rating achieved?

Minimum Standards for BREEAM ‘Very Good’ rating Achieved?	Achieved?

Man 01: Sustainable procurement	Y
Man 04a: Stakeholder participation	Y
Hea 01: Visual comfort	Y
Hea 02: Indoor air quality	Y
Hea 04: Water quality	Y
Ene 02a: Energy monitoring	Y
Wat 01: Water consumption	Y
Wat 02a: Water monitoring	Y

SOURCE:

HTTP://WWW.BREEAM.ORG/BREEAMINT2013SCHEMEDOCUMENT/CONTENT/03_SCORINGRATING/SCORING.HTM#BREEAM_RATING_BENCHMARKS

APPENDIX D

Minimum BREEAM standards by rating level

Table for BREEAM flexibility

Minimum BREEAM standards by rating level

BREEAM issue	PASS	GOOD	VERY GOOD	EXCELLENT	OUTSTANDING
Man 01: Sustainable procurement	One credit	One credit	One credit	One credit	Two credits
Man 02: Responsible construction practices	None	None	None	One credit	Two credits
Man 04a: Stakeholder participation	None	One credit (Building user information)	One credit (Building user information)	One credit (Building user information)	One credit (Building user information)

BREEAM issue	PASS	GOOD	VERY GOOD	EXCELLENT	OUTSTANDING
Man 04b: Stakeholder participation	None	One credit (Home user information)	One credit (Home user information)	One credit (Home user information)	Three credits (Home user information, and Inclusive and accessible design)
Hea 01: Visual comfort	Criterion 1 only	Criterion 1 only	Criterion 1 only	Criterion 1 only	Criterion 1 only
Hea 02: Indoor air quality	Criterion 1 only	Criterion 1 only	Criterion 1 only	Criterion 1 only	Criterion 1 only
Hea 04: Water quality	Criterion 1 only	Criterion 1 only	Criterion 1 only	Criterion 1 only	Criterion 1 only
Hea 08: Private space	None	None	None	None	One credit
Ene 01: Reduction of CO_2 emissions	None	None	None	Six credits	Ten credits
Ene 02a: Energy monitoring	None	None	One credit	One credit	One credit

BREEAM issue	PASS	GOOD	VERY GOOD	EXCELLENT	OUTSTANDING
			(First sub-metering credit)	(First sub-metering credit)	(First sub-metering credit)
Ene 04: Low or zero carbon technologies	None	None	None	One credit	One credit
Wat 01: Water consumption	None	None	One credit	One credit	Two credits
Wat 02: Water monitoring	None	Criterion 1 only	Criterion 1 only	Criterion 1 only	Criterion 1 only
Mat 03: Responsible Sourcing	None	None	None	None	Criterion 1 only
Wst 01: Construction waste management	None	None	None	None	One credit

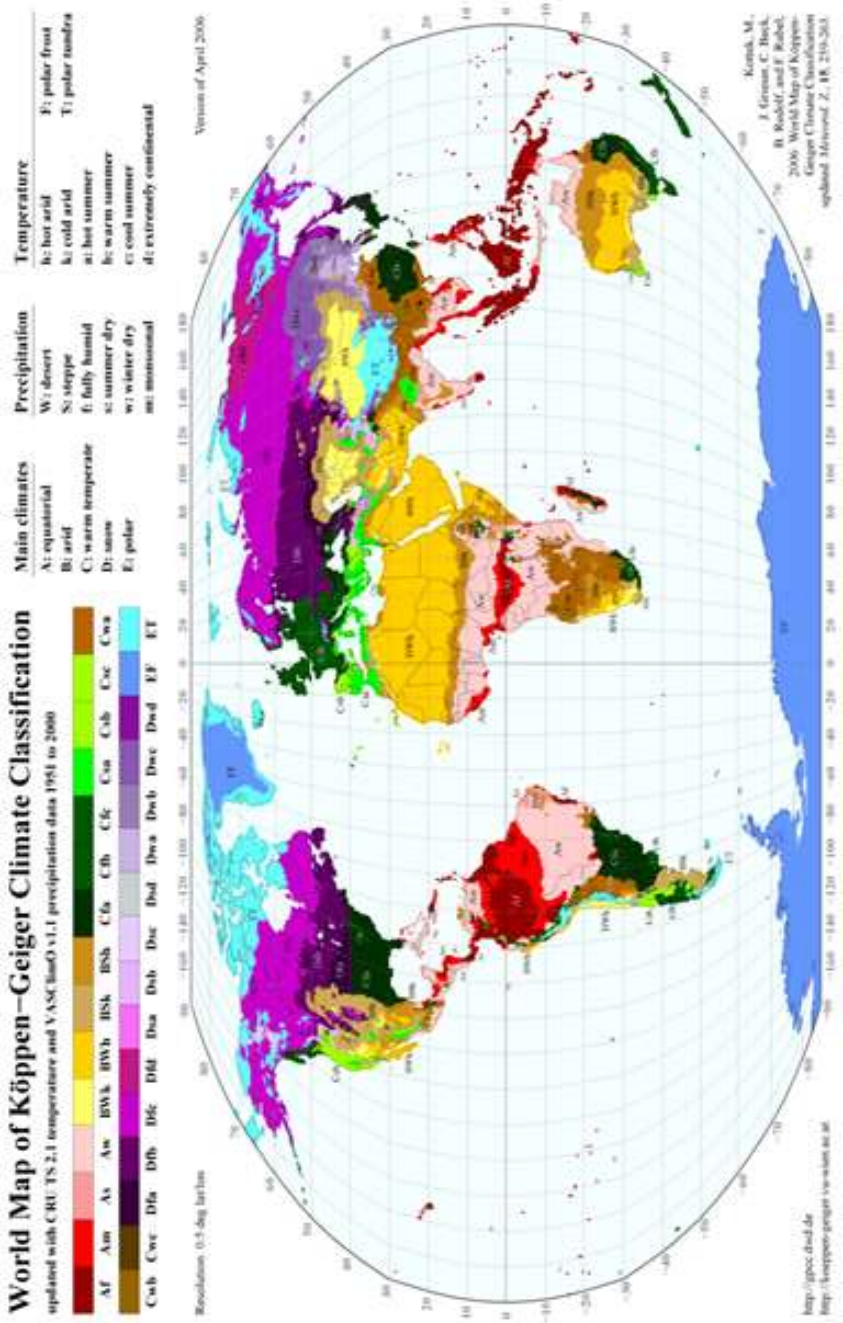
BREEAM issue	PASS	GOOD	VERY GOOD	EXCELLENT	OUTSTANDING
Wst 03a&b: Operational waste	None	None	None	One credit	One credit

SOURCE:

http://www.breeam.org/BREEAMInt2013SchemeDocument/content/03_scoringrating/scoring.htm#BREEAM_rating_benchmarks

APPENDIX E

World Map of Köppen-Geiger Climate Classification

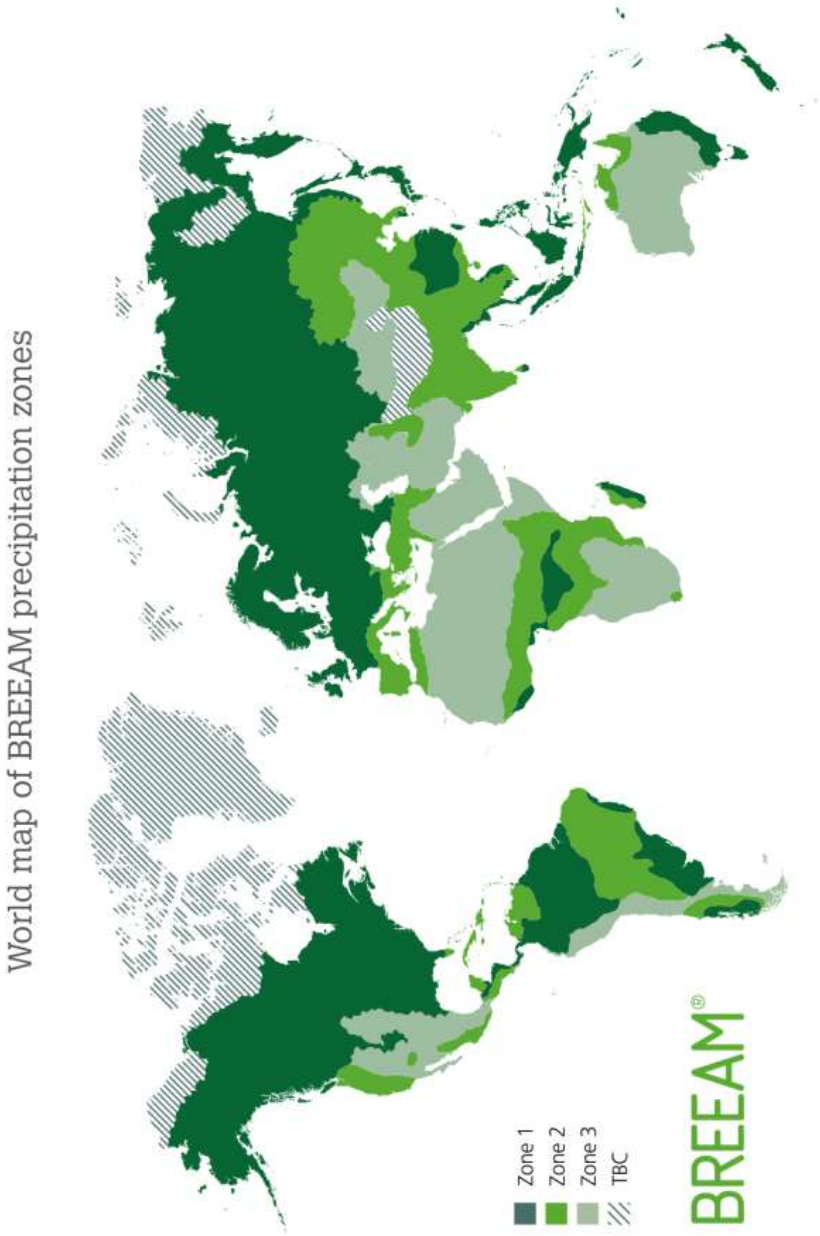


Source:

http://www.breeam.org/BREEAMInt2013SchemeDocument/#03_scoringrating/scoring.htm%3FTocPath%3D_5

APPENDIX F

World map of BREEAM precipitation zones



SOURCE:

http://www.breeam.org/BREEAMInt2013SchemeDocument/#03_scoringrating/scoring.htm%3F

TocPath%3D_____5

APPENDIX G

HQE Certification for Buildings Under Construction - PREREQUISITES 1

PREREQUISITES 1

MANDATORY DOCUMENTS
Applicant's Commitment (§1)

- ☐ Analysis of the site A.1
- ☐ Collecting the needs of stakeholders
- ☐ Collecting regulatory and other requirements
- ☐ Assessing investment and operating costs
- ☐ Targeted environmental performance profile of the project (§1.1)
- ☐ Commitment document (§1.2)

Implementation and Operation (§2)

- ☐ Planning the project (§2.1)
- ☐ Assigning the employees and stakeholders' tasks, responsibilities and authorities (§2.2)
- ☐ Assessing the employees and stakeholders – Training (§2.3)
- ☐ Stakeholders' contracts (§2.4)
- ☐ Communicating with stakeholders and parties involved (§2.5)

Management (§3)

- ☐ Results of reviews and all resulting actions (§3.1)
- ☐ EPB assessments (§3.2)
- ☐ Procedure regarding corrections and corrective actions (§3.3)
- ☐ Decisions and actions resulting from changes (§3.3)
- ☐ Records regarding non-achievement of the EPB and/or failure to meet a requirement of the Project Environmental Management and identifying its cause (§3.3)
- ☐ Corrective actions implemented (§3.3)

Capitalisation (§4)

- ☐ Final report
- ☐ Information on the satisfaction (or dissatisfaction) of the clients and other stakeholders

"PROJECT" DOCUMENTS

- ☐ Low environmental impact worksite agreementA.1 B

- ☐ Programme A.2
- ☐ Design documents A.3
- ☐ Contractual documents
- ☐ Works contract A.4
- ☐ Minutes of worksite meetings
- ☐ Expected upkeep and maintenance plan (or maintenance notebook) A.5
- ☐ Day-to-day notebook of the building A.6
- ☐ Informative documents for occupants A.7

DOCUMENTS FOR FUTURE USERS

- ☐ Future user Specifications A.8
- ☐ Low environmental impact worksite agreement for future users A.9

Source:

(Cerway 2014)

APPENDIX H

HQE Certification for Buildings Under Construction - PREREQUISITES 2

PREREQUISITES 2

TARGET 1 – THE BUILDING'S RELATIONSHIP WITH ITS IMMEDIATE ENVIRONMENT

1.1.1. Ensure consistency between the layout of the plot and the community's policy

1.1.4. Control travel methods and encourage those which are the least polluting for optimal functionality

TARGET 2 – INTEGRATED CHOICES OF CONSTRUCTION PRODUCTS, SYSTEMS AND PROCESSES

2.1.1. Choose products, systems or processes whose characteristics are verified and compatible with the usage

2.1.2. Adaptability of the building over time based on its forecast lifespan and usages

TARGET 3 – LOW ENVIRONMENTAL IMPACT WORKSITE

3.1.1. Identify and quantify the worksite waste by type

TARGET 4 – ENERGY MANAGEMENT

4.1.1. Improve the ability of the building to reduce its energy demand

4.2.1. Reduce primary energy consumption due to heating, cooling, lighting, Service Water Heating, ventilation and ancillary systems linked to user comfort

4.2.4. Use of renewable energy

4.3.1. CO2 equivalent quantities produced due to energy use

TARGET 5 – WATER MANAGEMENT

5.1.1. Limit water demand for sanitary use

5.1.3. Determine the overall consumption of drinking and non-drinking water

5.2.2. Manage rainwater in an alternative manner

5.3.1. Control wastewater discharges

TARGET 6 – OPERATIONAL WASTE MANAGEMENT

6.2.1. Adequate sizing of waste rooms/areas *

6.2.2. Guarantee the hygiene of the waste rooms/areas

TARGET 7 – MAINTENANCE AND DURABILITY OF ENVIRONMENTAL PERFORMANCE

7.1.1 Design the building so as to facilitate maintenance/servicing interventions during the building's operation

7.2.1. Make metering devices available to monitor energy consumption

7.2.2. Make metering devices available to monitor water consumption

TARGET 8 – HYGROTHERMAL COMFORT

8.1.1. Improve the building's ability to provide satisfying hygrothermal comfort conditions

8.2.1. Define/achieve an appropriate temperature level within spaces

8.2.5. Control hygrometry

8.3.1 Ensure a minimum thermal comfort level of thermal comfort

8.4.1. Define/achieve an appropriate temperature level in the spaces

TARGET 9 – ACOUSTIC COMFORT

9.1.1. Optimize the acoustic quality of spaces

TARGET 10 – VISUAL COMFORT

10.1.1. Have access to daylight in sensitive spaces

10.1.2. Have access to outdoor views in sensitive spaces

10.1.3. Creation of spaces with a minimum level of natural lighting and optimum treatment of the quality of natural light

10.2.1. Have optimal lighting levels

10.2.3. Avoid glare due to artificial lighting and seek a balance between light sources from the surrounding light environment

TARGET 11 – OLFACTORY COMFORT

Same as 13.1

TARGET 12 – HEALTH QUALITY OF SPACES

12.1.1. Identify sources of electromagnetic emissions

12.2.1. Create special health conditions (except maintenance rooms)

12.2.2. Optimize the health conditions of maintenance rooms

TARGET 13 – HEALTH QUALITY OF AIR

13.1.1. Provide air flows suitable for the activity of the rooms

13.2.1. Identify and reduce the effects of internal and external sources of pollution

TARGET 14 – HEALTH QUALITY OF WATER

14.1.1. Choose materials compatible with the nature of the water being distributed

14.1.3. Provide structure and signs to the indoor network based on water usage

14.2.1. Ensure a sufficient temperature in the DHW distribution and production networks in order to minimize the risk of legionella

14.4.1. Treat polluted bathing water

Source:(Cerway 2014)

APPENDIX I

Evaluation system of GRIHA criteria

Table 29 Evaluation system of GRIHA criteria

Criteria	Description	Points	
Criterion 1	Site Selection	1	Partly mandatory
Criterion 2	Preserve and protect landscape during construction/compensatory depository forestation.	5	Partly mandatory, if applicable
Criterion 3	Soil conservation (post construction)	2	
Criterion 4	Design to include existing site features	4	
Criterion 5	Reduce hard paving on site	2	Partly mandatory
Criterion 6	Enhance outdoor lighting system efficiency	3	
Criterion 7	Plan utilities efficiently and optimize on-site circulation efficiency	3	
Criterion 8	Provide, at least, minimum level of sanitation/safety facilities for construction workers	2	Mandatory
Criterion 9	Reduce air pollution during construction	2	Mandatory
Criterion 10	Reduce landscape water demand	3	
Criterion 11	Reduce building water use	2	
Criterion 12	Efficient water use during construction	1	
Criterion 13	Optimize building design to reduce conventional energy demand	8	Mandatory
Criterion 14	Optimize energy performance of building within specified comfort limits	16	Partly mandatory
Criterion 15	Utilization of fly-ash or equivalent industrial/agricultural waste as recommended by BIS in building structures	6	
Criterion 16	Reduce embodied energy of construction is reduced by adopting material efficient technologies and/or low-energy materials	4	

Criterion 17	Use low-energy materials in Interiors	4	
Criterion 18	Renewable energy utilization	5	Partly mandatory
Criterion 19	Renewable energy based hot water system	3	
Criterion 20	Waste water treatment	2	
Criterion 21	Water recycle and reuse (including rainwater)	5	
Criterion 22	Reduction in waste during construction	1	
Criterion 23	Efficient Waste segregation	1	
Criterion 24	Storage and disposal of wastes	1	
Criterion 25	Resource recovery from waste	2	
Criterion 26	Use of low-VOC paints/adhesives/sealants	3	
Criterion 27	Minimize ozone depleting substances	1	Mandatory
Criterion 28	Ensure water quality	2	Mandatory
Criterion 29	Acceptable outdoor and indoor noise levels	2	
Criterion 30	Tobacco and smoke control	1	Mandatory
Criterion 31	Provide at least the minimum level of accessibility for persons with disabilities	1	
Criterion 32	Energy audit and validation	NA	Mandatory
Criterion 33	Operation and Maintenance	2	Mandatory
Criterion 34	Innovation Points	4	

SOURCE: (MINISTRY OF NEW AND RENEWABLE ENERGY, GOVERNMENT OF INDIA AND THE ENERGY AND RESOURCES INSTITUTE 2010)

APPENDIX J

SVAGRIHA mandatory sub-group points table

Sub-Group	Maximum points	Minimum points to be achieved
Landscape	6	3
Architecture & Energy	21	11
Water & waste	11	6
Materials	8	4
Lifestyle	4	1

SOURCE: (THE ENERGY AND RESOURCES INSTITUTE, AND ASSOCIATION FOR DEVELOPMENT AND RESEARCH OF SUSTAINABLE HABITATS 2011)

APPENDIX K

SKA -The Good Practice Measures for Offices

Ska rank	Issue	Ska ID	Good Practice Measure (GMP)
1	Energy & CO2	P10	Reduce lighting energy in use
2	Energy & CO2	P11	Reduce small power in use
3	Water	P08	Reduce water in use
4	Energy & CO2	D01	Energy efficient lighting
5	Energy & CO2	D02	Lighting controllability
6	Energy & CO2	E01	Lighting controls
7	Water	E12	New low flush WCs
8	Water	E23	Existing low flush WCs
9	Waste	D60	Designing out waste
10	Energy & CO2	E02	Energy efficient lamps
11	Materials	M05	Hardwoods
12	Waste	D15	Reduce workstations and tables sent to landfill
13	Waste	D16	Reduce chairs sent to landfill

14	Pollution	D22	Low-GWP insulation
15	Pollution	D23	Low-impact refrigerants
16	Project Delivery	D44	CCS registration
17	Transport	D41	Cycle parking
18	Energy & CO2	E05	Energy efficient heat pumps
19	Wellbeing	D28	Thermal comfort assessment
20	Water	E14	Efficient taps
21	Materials	D20	Timber
23	Waste	D17	Reduce storage units sent to landfill
24	Wellbeing	D30	Lighting design
25	Wellbeing	D31	Daylight glare control
26	Waste	D14	Reduce floor finishings sent to landfill
27	Energy & CO2	E07	Pipework insulation
28	Energy & CO2	E08	Tenancy sub-metering
29	Energy & CO2	E04	Energy efficient light fittings
30	Energy & CO2	E06	HVAC zone controls
31	Project Delivery	D56	Soft landings framework
32	Waste	D11	Reduce timber sent to landfill

33	Waste	D13	Reduce ceilings sent to landfill
34	Water	E16	Showers
35	Materials	M07	Raised flooring systems
36	Waste	D12	Reduce partitions sent to landfill
37	Waste	D48	Reduce doors sent to landfill
38	Waste	D10	Reduce masonry sent to landfill
39	Waste	P03	Reduce construction & demolition (C&D) waste sent to landfill
40	Wellbeing	D33	Ventilation rates
41	Energy & CO2	E09	End-use sub-metering
42	Wellbeing	D40	CO2 monitoring
43	Water	E17	Water meter
44	Energy & CO2	E22	IT and comms room energy consumption
45	Materials	M01	Blockwork
46	Materials	M10	Suspended ceilings
47	Materials	M08	Partitions
48	Energy & CO2	D03	Energy efficient HVAC
49	Energy & CO2	D66	Energy modelling

50	Wellbeing	D29	Acoustic design
51	Materials	M12	Soft flooring
52	Wellbeing	D32	Occupant HVAC control
53	Project Delivery	D45	Building user guide
54	Transport	D42	Showers
55	Materials	M09	Glazed partitions
56	Materials	M14	Paints
57	Pollution	D57	Refrigerant leak prevention
58	Waste	P04	Increase recycling of construction & demolition (C&D) waste
59	Energy & CO2	D53	Electrical management
60	Pollution	D24	Refrigerant leak detection
61	Materials	M11	Hard flooring
62	Materials	M06	Joinery
63	Wellbeing	D63	Low VOC finishes
64	Water	E18	Water management software
65	Waste	P05	Reduce total waste in use
66	Waste	D08	Recyclable waste storage space

67	Waste	D09	SWMP
68	Energy & CO2	E11	Efficient boilers
69	Energy & CO2	D04	Daylighting
70	Energy & CO2	E24	Energy efficient hand-dryers
71	Energy & CO2	D05	Energy efficient DHW
72	Waste	D68	Reduce mechanical & electrical services materials sent to landfill
73	Materials	M04	Insulation
74	Water	E19	Sanitary supply shut-off
75	Materials	M18	Kitchen fittings
76	Materials	M19	Workstations and tables
77	Waste	P06	Increase recycling of waste in use
78	Water	E20	Leakage detection devices
79	Materials	M22	Other loose ancillary furniture items
80	Materials	M17	Doors
81	Materials	M20	Chairs
82	Materials	M28	WC cubicle
83	Materials	M02	Bricks

84	Materials	M03	Screed
85	Wellbeing	D36	Cleaning of existing air supply ductwork
86	Energy & CO2	P01	Reduce fit-out energy use
87	Wellbeing	D35	Printer-copier equipment area ventilation
88	Materials	M21	Storage units
89	Water	E21	Leakage pressure reducing valve controller
90	Materials	M15	Polishes & varnishes
91	Wellbeing	D37	Fine air filters
92	Materials	M13	Hard wall covering
93	Transport	D59	Construction phase CO2 emissions
94	Water	P07	Reduce fit-out water use
95	Transport	D43	Cyclist lockers
96	Wellbeing	D62	Staff breakout space
97	Materials	M23	Window Treatments
98	Wellbeing	D39	Outside views
99	Materials	M24	Paper and towel dispensers
100	Pollution	D26	Reduce light pollution
101	Materials	M16	Wall covering

102	Materials	D21	Total recycled materials
103	Pollution	D27	Refrigerant recovery
104	Materials	D19	Materials specification
105	Energy & CO2	P09	Display Energy Certificates (DECs)
106	Pollution	D25	Limiting plant noise
107	Pollution	D58	NOX emissions
108	Wellbeing	D64	VOC monitors
109	Wellbeing	P12	Fit-out VOC monitoring

SOURCE: (RICS - ROYAL INSTITUTE OF CHARTERED SURVEYORS 2013), 6-8.

APPENDIX L

Cornell Campus Buildings & Landmarks with Historic Designations

Table 30 Cornell Campus Buildings & Landmarks with Historic Designations

Rice Hall	National Register
Bailey Hall	National Register & Local Landmark
Morrill Hall	National Register
Sage Chapel	Local Landmark
A.D. White House	National Register
Caldwell Hall	National Register & Local Landmark
Computing & Communications Center (Formerly Comstock Hall)	National Register & Local Landmark
Fernow Hall	National Register & Local Landmark
South Avenue 13, Delta Kappa Eps	National Register
Sage Graduate Hall	Local Landmark
Barnes Hall	Local Landmark
Wing Hall	National Register
Foundry	Local Landmark
Stewart Avenue Bridge	Local Landmark
Llenroc (Delta Phi)	National Register & Local Landmark
Ezra Cornell Statue	Local Landmark
Andrew Dickson White Statue	Local Landmark

Source: Campus Buildings & Landmarks with Historic Designations (Cornell University 2006)

APPENDIX M

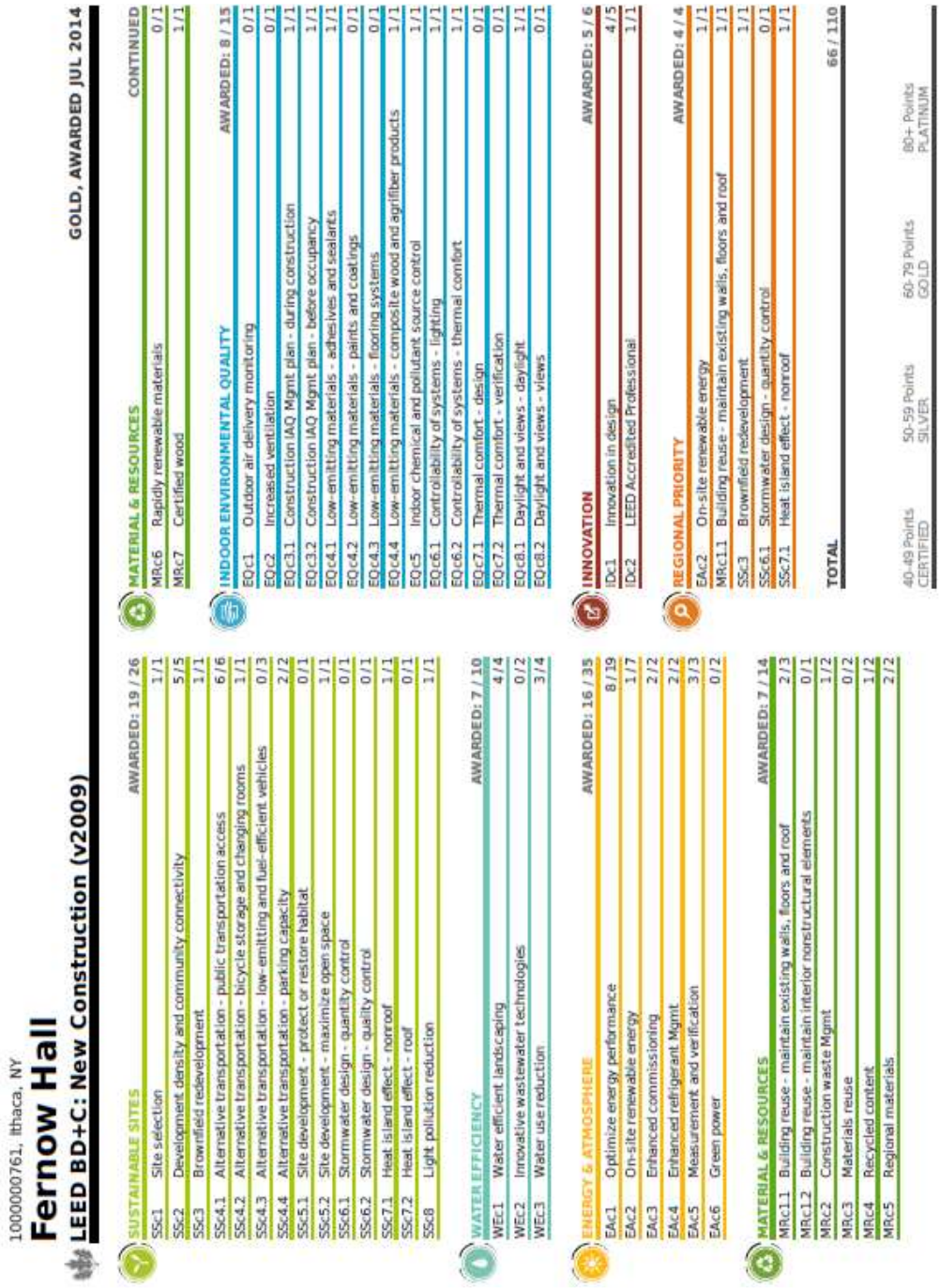
LEED Certifications of buildings at Cornell University

Table 31 LEED Certifications of buildings at Cornell University

Name of building	LEED Rating
Alice H. Cook House	Certified
Combined Heat & Power Plant Office	GOLD
Fernow Hall	GOLD
Human Ecology Building	PLATINUM
Law School Learning Center Addition	PLATINUM
Marriot Learning Center	GOLD
Martha Van Rennselaer '33	GOLD
Milstein Hall	GOLD
NYS Veterinary Diagnostic Laboratory	GOLD
Physical Sciences Building	GOLD
Plantations Brian C. Nevin Welcome Center	GOLD
Rice Hall	GOLD(pursuing)
Riley-Robb Hall Biofuels Research Laboratory	GOLD
Stocking Hall	GOLD(pursuing)
Teaching Dairy Barn	Certified
Weill Hall	GOLD

SOURCE: (CAMPUS SUSTAINABILITY OFFICE, CORNELL UNIVERSITY N.D.)

Fernow Hall - LEED certification Score Card



1000000761, Ithaca, NY

Fernow Hall

LEED BD+C: New Construction (v2009)

GOLD, AWARDED JUL 2014

SUSTAINABLE SITES		AWARDED: 19 / 26
SSc1	Site selection	1 / 1
SSc2	Development density and community connectivity	5 / 5
SSc3	Brownfield redevelopment	1 / 1
SSc4.1	Alternative transportation - public transportation access	6 / 6
SSc4.2	Alternative transportation - bicycle storage and changing rooms	1 / 1
SSc4.3	Alternative transportation - low-emitting and fuel-efficient vehicles	0 / 3
SSc4.4	Alternative transportation - parking capacity	2 / 2
SSc5.1	Site development - protect or restore habitat	0 / 1
SSc5.2	Site development - maximize open space	1 / 1
SSc6.1	Stormwater design - quantity control	0 / 1
SSc6.2	Stormwater design - quality control	0 / 1
SSc7.1	Heat island effect - nonroof	1 / 1
SSc7.2	Heat island effect - roof	0 / 1
SSc8	Light pollution reduction	1 / 1

WATER EFFICIENCY		AWARDED: 7 / 10
WEc1	Water efficient landscaping	4 / 4
WEc2	Innovative wastewater technologies	0 / 2
WEc3	Water use reduction	3 / 4

ENERGY & ATMOSPHERE		AWARDED: 16 / 35
EAc1	Optimize energy performance	8 / 19
EAc2	On-site renewable energy	1 / 7
EAc3	Enhanced commissioning	2 / 2
EAc4	Enhanced refrigerant Mgmt	2 / 2
EAc5	Measurement and verification	3 / 3
EAc6	Green power	0 / 2

MATERIAL & RESOURCES		AWARDED: 7 / 14
MRc1.1	Building reuse - maintain existing walls, floors and roof	2 / 3
MRc1.2	Building reuse - maintain interior nonstructural elements	0 / 1
MRc2	Construction waste Mgmt	1 / 2
MRc3	Materials reuse	0 / 2
MRc4	Recycled content	1 / 2
MRc5	Regional materials	2 / 2

MATERIAL & RESOURCES		CONTINUED
MRc6	Rapidly renewable materials	0 / 1
MRc7	Certified wood	1 / 1

INDOOR ENVIRONMENTAL QUALITY		AWARDED: 8 / 15
EQc1	Outdoor air delivery monitoring	0 / 1
EQc2	Increased ventilation	0 / 1
EQc3.1	Construction IAQ Mgmt plan - during construction	1 / 1
EQc3.2	Construction IAQ Mgmt plan - before occupancy	1 / 1
EQc4.1	Low-emitting materials - adhesives and sealants	1 / 1
EQc4.2	Low-emitting materials - paints and coatings	0 / 1
EQc4.3	Low-emitting materials - flooring systems	0 / 1
EQc4.4	Low-emitting materials - composite wood and agrifiber products	1 / 1
EQc5	Indoor chemical and pollutant source control	1 / 1
EQc6.1	Controllability of systems - lighting	1 / 1
EQc6.2	Controllability of systems - thermal comfort	1 / 1
EQc7.1	Thermal comfort - design	0 / 1
EQc7.2	Thermal comfort - verification	0 / 1
EQc8.1	Daylight and views - daylight	1 / 1
EQc8.2	Daylight and views - views	0 / 1

INNOVATION		AWARDED: 5 / 6
IDc1	Innovation in design	4 / 5
IDc2	LEED Accredited Professional	1 / 1

REGIONAL PRIORITY		AWARDED: 4 / 4
EAc2	On-site renewable energy	1 / 1
MRc1.1	Building reuse - maintain existing walls, floors and roof	1 / 1
SSc3	Brownfield redevelopment	1 / 1
SSc6.1	Stormwater design - quantity control	0 / 1
SSc7.1	Heat island effect - nonroof	1 / 1

TOTAL		66 / 110

40-49 Points	50-59 Points	60-79 Points	80+ Points
CERTIFIED	SILVER	GOLD	PLATINUM

SOURCE: LEED ONLINE PROJECT DOCUMENTS

APPENDIX O

LEED 2009 POINTS TABLE FOR CREDIT EAC1 OPTIMIZE ENERGY PERFORMANCE

Table 32 LEED 2009 Points table for Credit EAc1 Optimize energy performance

New Buildings	Existing Building Renovations	Points
12%	8%	1
14%	10%	2
16%	12%	3
18%	14%	4
20%	16%	5
22%	18%	6
24%	20%	7
26%	22%	8
28%	24%	9
30%	26%	10
32%	28%	11
34%	30%	12
36%	32%	13
38%	34%	14
40%	36%	15
42%	38%	16
44%	40%	17
46%	42%	18
48%	44%	19

SOURCE:

http://www.usgbc.org/node/1731022?return=/credits/new-construction/v2009/energy-&view=language

APPENDIX P

Minimum renewable energy percentage for each point threshold LEED Credit EAc2 On-site renewable energy

Table 33 Minimum renewable energy percentage for each point threshold LEED Credit EAc2 On-site renewable energy

Percentage Renewable Energy	Points
1%	1
3%	2
5%	3
7%	4
9%	5
11%	6
13%	7

SOURCE:

HTTP://WWW.USGBC.ORG/NODE/1731246?RETURN=/CREDITS/NEW-CONSTRUCTION/V2009/ENERGY-&VIEW=LANGUAGE

APPENDIX Q

A. VOC limits for adhesives and sealants LEED 2009 Credit EQc4.1 Low-emitting materials - adhesives and sealants

Table 34 VOC limits for adhesives and sealants LEED 2009 Credit EQc4.1 Low-emitting materials - adhesives and sealants

Architectural Applications	VOC Limit		
(g/L less water)	Specialty Applications	VOC Limit	
(g/L less water)			
Indoor carpet adhesives	50	PVC welding	510
Carpet pad adhesives	50	CPVC welding	490
Wood flooring adhesives	100	ABS welding	325
Rubber floor adhesives	60	Plastic cement welding	250
Subfloor adhesives	50	Adhesive primer for plastic	550
Ceramic tile adhesives	65	Contact adhesive	80
VCT and asphalt adhesives	50	Special purpose contact adhesive	250
Drywall and panel adhesives	50	Structural wood member adhesive	140
Cove base adhesives	50	Sheet applied rubber lining operations	850

Multipurpose construction adhesives	70	Top and trim adhesive	250
Structural glazing adhesives	100		
Substrate Specific Applications	VOC Limit		
(g/L less water)	Sealants	VOC Limit	
(g/L less water)			
Metal to metal	30	Architectural	250
Plastic foams	50	Roadway	250
Porous material (except wood)	50	Other	420
Wood	30		
Fiberglass	80		
Sealant Primers	VOC Limit (g/L less water)		
Architectural, nonporous	250		
Architectural, porous	775		
Other	750		

Adhesives, Sealants and Sealant Primers must comply with South Coast Air Quality Management District (SCAQMD) Rule #1168. Volatile organic compound (VOC) limits listed in the table above correspond to an effective date of July 1, 2005 and rule amendment date of January 7, 2005. This table excludes adhesives and sealants integral to the water-proofing system or that are not building related.

SOURCE:

http://www.usgbc.org/node/1732510?return=/credits/new-construction/v2009/indoor-environmental-quality&view=language

B. VOC limits for Aerosol adhesives LEED 2009 Credit EQc4.1 Low-emitting materials - adhesives and sealants

Table 35 VOC limits for Aerosol adhesives LEED 2009 Credit EQc4.1 Low-emitting materials - adhesives and sealants

Aerosol Adhesives	VOC weight (g/L minus water)
General purpose mist spray	65% VOCs by weight
General purpose web spray	55% VOCs by weight
Special purpose aerosol adhesives (all types)	70% VOCs by weight

Aerosol Adhesives must comply with Green Seal Standard for Commercial Adhesives GS-36 requirements in effect on October 19, 2000

SOURCE: HTTP://WWW.USGBC.ORG/NODE/1732510?RETURN=/CREDITS/NEW-CONSTRUCTION/V2009/INDOOR-ENVIRONMENTAL-QUALITY&VIEW=LANGUAGE

APPENDIX R

ESTIMATION OF BREEAM SCORE FOR FERNOW HALL

APPENDIX S

Estimation of BREEAM score and ratings for Fernow Hall

BREEAM Section	Credits Achieved	Credits Available	% of Credits Achieved	Section Weighting (fully fitted)*	% Section Score
Management	14	20	70	0.12	8
Health and Wellbeing	6	22	27	0.15	4
Energy	11	34	32	0.15	5
Transport	9	11	82	0.09	7
Water	4	9	44	0.07	3
Materials	4	14	29	0.135	4
Waste	4	13	31	0.085	3
Land Use and Ecology	2	5	40	0.1	4
Pollution	8	13	62	0.1	6
Innovation	1	10	10	0.1	1
Final BREEAM score					**45**
BREEAM Rating					**GOOD**

Minimum standards for a BREEAM Very Good rating

Standards	Achieved?
Man 03: Responsible construction practices	**Y**
Ene 02: Energy monitoring	Y
Wat 01: Water consumption	Y
Wat 02: Water monitoring	Y
Mat 03: Responsible sourcing of materials	Y

Management (TOTAL)	14/21	
Summary	**Achieved/ Total Credits**	**Credit summary**
Man 01 Project brief and design	4/4	
		Stakeholder consultation covering project delivery and relevant third parties. Sustainability champion appointed to facilitate the setting, monitoring and achievement of BREEAM performance target(s) for the project.
Man 02 Life cycle cost and service life planning	0/4	
		Recognising and encouraging the use of life cycle costing and service life planning and the sharing of data to raise awareness and understanding.
Man 03 Responsible construction practices	3/6	
		The principal contractor demonstrates sound environmental management practices and consideration for neighbours across their activities on site. Site related energy, water and transport impacts are monitored and reported to ensure ongoing compliance during the Refurbishment, Handover and Close Out stages and to improve awareness and understanding for future projects.
Man 04 Commissioning and handover	4/4	
		Schedule of commissioning including optimal timescales and appropriate testing and commissioning of all building services systems and building fabric in line with best practice. Inspecting, testing, identifying and rectifying defects via an appropriate method.
Man 05 Aftercare	3/3	
		Provision of a non-technical Building User Guide, user training and operator training timed appropriately around handover and proposed occupation. Provision of necessary infrastructure and resources to provide aftercare support to the building occupier(s). Seasonal commissioning activities completed over a minimum 12 month period, once the building becomes substantially occupied. The client or building occupier commit to carrying out a post occupancy evaluation (POE) exercise 1-yr after initial building occupation and to disseminate the findings in terms of the building's post occupancy performance.

6.0 Health and Wellbeing (TOTAL)	6/22	
Summary	**Achieved/ Total Credits**	**Credit summary**
Hea 01 Visual comfort	4/7	
		Potential for disabling glare has been designed out of all relevant building areas. Good practice daylighting levels have been met. Floor space in relevant building areas has an adequate view out to reduce eye strain and provide a link to the outside
Hea 02 Indoor air quality	1/2	
		Internal and external lighting systems are designed to avoid flicker and provide appropriate illuminance (lux) levels. Internal lighting is zoned to allow for occupant control.
Hea 03 Safe containment in laboratories	1/1	
		Minimising sources of air pollution through careful design specification and planning.
		Building ventilation strategy is designed to be flexible and adaptable to potential future building occupant needs and climatic scenarios.
		Production of an objective risk assessment of the proposed laboratory facilities.
		Containment devices such as fume cupboards meet best practice safety and performance requirements and objectives.
		Containment level 2 and 3 laboratory facilities to meet best practice safety and performance criteria where specified.
Hea 04 Thermal comfort	0/1	
		Thermal modelling carried out to appropriate standards. Projected climate change scenario(s) considered as part of the thermal model. The thermal modelling analysis has informed the temperature control strategy for the building and its users.
Hea 07 Hazards	0/1	
		To conduct a risk assessment for natural hazards that may affect the building and the implementation of measures to mitigate any risks.

Energy (TOTAL)	11/34	
Summary	**Achieved/ Total Credits**	**Credit summary**
Ene 01 Reduction of energy use and carbon emissions	5	
Ene 02 Energy monitoring		NEED MORE DATA (Since LEED has awarded about 40% credits I awarded
	1	
		Sub-metering of major energy consuming systems
New TopicEne 06 Energy efficient transportation systems	5	

Transport (TOTAL)	9/11	
Summary	**Achieved/ Total Credits**	**Credit summary**
Tra 01 Sustainable transport accessibility	6	
		Up to three credits - Alternative transport measures
New TopicTra 02 Proximity to amenities	1	
New TopicTra 03 Cyclist facilities	NA	
New TopicTra 04 Maximum car parking capacity	2	

Water (TOTAL)	4/9	
Summary	**Achieved/ Total Credits**	**Credit summary**
Wat 01 Water consumption	3	precipitation zone 2 assumed
New TopicWat 02 Water monitoring	1	

Materials (TOTAL)	4/14	
Summary	**Achieved/ Total Credits**	**Credit summary**
New TopicMat 03 Responsible sourcing of materials	3	
New TopicMat 04 Insulation		
New TopicMat 06 Material Efficiency	1	

Waste (TOTAL)	4/13	
Summary	Achieved/ Total Credits	Credit summary
New TopicWst 01 Project waste management	3	
		Pre-refurbishment audit
		Reuse and direct recycling of materials
		Resource efficiency
		Diversion of resources from landfill
New TopicWst 03 Operational waste	1	

Land Use and Ecology (TOTAL)	2/5	
Summary	Achieved/ Total Credits	Credit summary
New TopicLE 02 Protection of ecological features	1	
New TopicLE 05 Long term impact on biodiversity	1	

Pollution (TOTAL)	8/13	
Summary	Achieved/ Total Credits	Credit summary
New TopicPol 01 Impact of refrigerants	4	
New TopicPol 03 Flood risk management and reducing surface water run-off	3	
New TopicPol 04 Reduction of night time light pollution	1	

Innovation (TOTAL)	1/10	
Summary	Achieved/ Total Credits	Credit summary
Wat 01 Water consumption	1	Take back the tap