THE REPUBLIC OF TURKEY
BAHÇEŞEHİR UNIVERSITY

GREEN PRESERVATION FOR HISTORIC BUILDINGS IN THE SCOPE OF LEED CERTIFICATION SYSTEM: ST. PIERRE HAN

Master's Thesis

DİLA VURAL

ISTANBUL, 2015

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This is to certify that we have read this thesis and that we find it fully adequate in scope, quality and content, as a thesis for the degree Master of Science.

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ABSTRACT

GREEN PRESERVATION FOR HISTORIC BUILDINGS IN THE SCOPE OF LEED CERTIFICATION SYSTEM: ST. PIERRE HAN

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Istanbul is a historical and cosmopolitan city, which consists of various historic buildings. These architectural, cultural and historical heritages of Istanbul play a major role in terms of city's cultural and urban identity. The influences of globalization have fostered the rise of heritage conservation as a growing desire to think about the long-term survivability of existing buildings and how they can be carefully maintained, innovatively reused by future generations. Istanbul has many historic buildings, which build a specific extent in terms of their production techniques due to the climatic factors and their urban context. In order to apply green building certification systems to the existing historic buildings in Istanbul, smart and original approaches are necessary. As a result of the rising awareness of building energy consumption and sustainability, numerous means of predicting performance and rating sustainability are developed. There are many methods to evaluate a building in terms of sustainability. The Leadership in Energy and Environmental Design (LEED) is one of the most populously used Performance Rating Systems. In this study, LEED 2009 for New Construction and Major Renovations (LEED-NC) is the guideline for greening St. Pierre Han in Galata as the case study building. The purpose of this research is to investigate potential advantages and problems of green adaptive re-use of historic buildings in Istanbul. Through a case study, this research not only explores a process for the sustainability evaluation and the certification of a historic building, but also aims to provide well-reasoned and evidence-based strategies for sustainable preservation of historic buildings based on LEED certification system.

Keywords: Sustainability, Historic Preservation, LEED, St. Pierre Han

ÖZET

SÜRDÜRÜLEBİLİRLİK AÇISINDAN TARİHİ BİR BİNANIN LEED SERTİFİKALANDIRMA SİSTEMİ KAPSAMINDA DEĞERLENDİRİLMESİ: ST. PIERRE HANI

Dila Vural

MİMARLIK

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İstanbul çeşitli tarihi binalardan oluşan tarihsel değeri olan kozmopolit bir şehirdir. Bu mimari, kültürel ve tarihi miras, şehrin kentsel ve kültürel yapısında önemli bir rol oynamaktadır. Küreselleşmenin etkisiyle gelecek nesillere uzun vadede sürdürülebilir, yenilikçi ve muhafaza edilebilir konut mirası bırakma ihtiyacı ve arzusu arttı. İstanbul, iklim özellikleri ve kentsel içeriğine uygun olarak üretilen geniş kapsamlı tarihi binalara sahiptir. Buradaki temel amaç, İstanbul'da mevcut olan tarihi nitelikteki binalara yeşil bina sertifikasını almalarını sağlayacak orijinal ve akıllı yaklaşımların uygulanmasıdır. Enerji tüketimi ve sürdürülebilirlik hakkında toplumsal bilincin artması üzerine binaların performansının yükselişinin sağlanabilmesi ve bunların tahmin edilebilmesi için çeşitli yollar geliştirilmiştir. Bir binanın sürdürülebilirliğinin değerlendirilmesi bakımından birden fazla yöntem bulunmaktadır. LEED (Leadership in Energy and Environmental Design) en sık kullanılan performans değerlendirme sistemlerinden biridir. Galata'da bulunan St. Pierre Han sözkonusu araştırmada vaka çalışması olarak, LEED 2009 Yeni Binalar ve Büyük Onarımlar Değerlendirme Sistemi (LEED-NC) kılavuzluğunda değerlendirilecektir. Bu tezin amacı, İstanbul'da bulunan tarihi binaların yeniden kullanıma uygulanabilir metodlarının avantajlı ve problemli yanlarının incelenmesidir. Tek bir vaka çalışması olarak, bu araştırmanın hedeflediği sonuç tarihi binalarda sadece sürdürülebilirliğin değerlendirilmesi ya da sertifikalandırmanın sağlanması olmamakla birlikte, bu binalarda sürdürülebilir korunmanın LEED sertifikalandırma sistemine dayanarak mantıklı ve kanıta dayanan stratejiler ortaya koymaktır.

Anahtar kelimeler: Sürdürülebilirlik, Tarihi Çevre Koruma, LEED, St. Pierre Hanı

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ABBREVIATIONS

ASHRAE	:	American Society of Heating, Refrigerating and Air Conditioning Engineers
BEP-TR	:	Calculation Methodology for Energy Performance of Buildings in Turkey
BRE	:	Building Research Establishment
BREEAM	:	Building Research Establishment Environmental Method
CFC	:	Chlorofluorocarbon
cm	:	Centimeter
CO_2	:	Carbon dioxide
EPA	:	United States Environmental Protection Agency
EPD	:	Environmental Product Declaration
ETS	:	Environmental Tobacco Smoke
GBCI	:	Green Building Council Institute
GHG	:	Greenhouse Gas
HVAC	:	Heating, Ventilation and Air Conditioning
ITU	:	Istanbul Technical University
LCA	:	Life Cycle Analysis
LEED	:	Leadership in Energy and Environmental Design
LEED AP	:	LEED Accredited Professional
km	:	Kilometer
lux	:	A Unit of Illumination
m	:	Meter
m^2	:	Square Meter
SEEB-TR	:	Sustainable Energy Efficient Buildings in Turkey
SRI	:	Solar Reflectance Index
St	:	Saint
USGBC	:	United States Green Building Council
VLT	:	Visible Light Transmission
VOC	:	Volatile Organic Compounds
WFR	:	Window to Floor Ratio

1. INTRODUCTION

Istanbul as a cosmopolitan city has many architecturally significant structures. Built on two continents, Istanbul is a melting pot of civilizations as well as religions. Consequently, the city consists of various historic buildings dating to the Byzantine, Genoese, Ottoman and modern Turkish periods. The architectural, cultural and historical heritage in Istanbul is of capital importance in terms of cultural and urban identity. The influences of globalization have fostered the rise of heritage conservation as an increasing tendency to preserve the past for strengthening cultural and urban identity. Historic buildings, which are unsuitable for their programmatic requirements are preserved while adding contemporary, adaptive and prestigious new functions. Some significant samples for the preservation and functional adaptability of historic buildings in Istanbul are Salt Repository in Kasımpaşa, SALT Galata, campuses of Bilgi and Kadir Has universities, Rahmi Koç Museum and Tophane-i Amire.

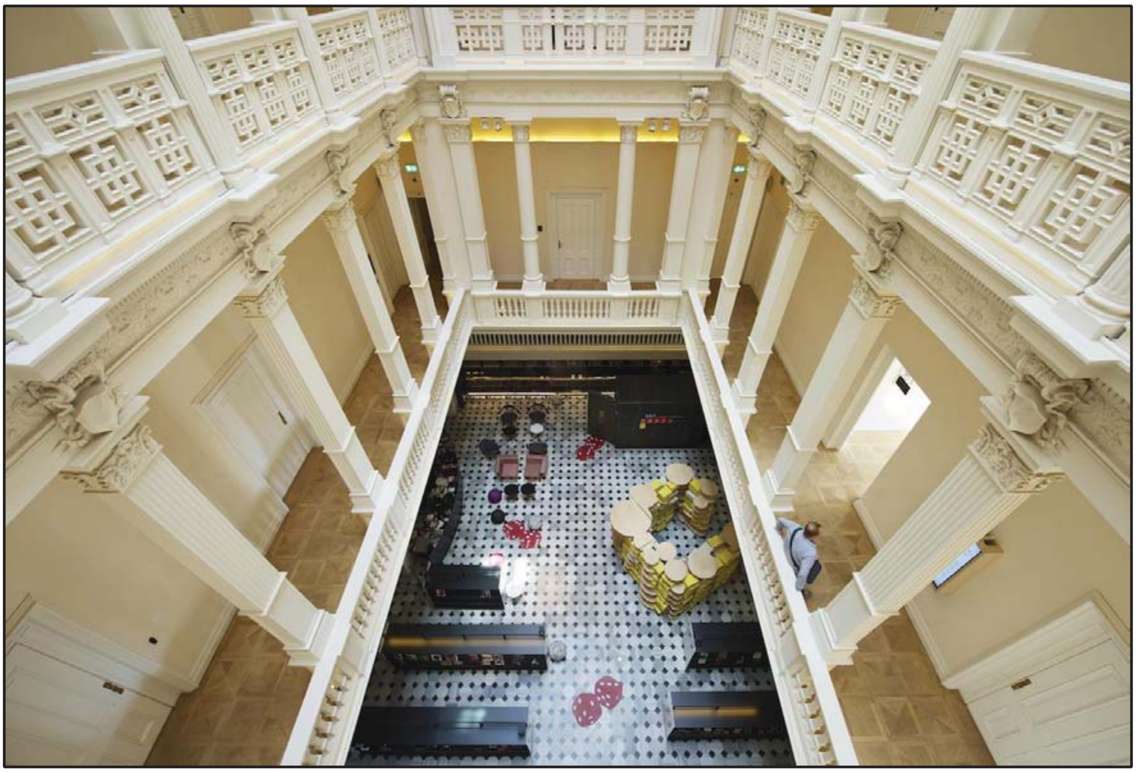
Figure 1.1: Salt Repository, 2011.

Source: Cemal Emden, http://ad009cdnb.archdaily.net. [Accessed 2 March 2014]

The 170-year-old salt repository building located in the old industrial district of Kasımpaşa, formerly owned by TEKEL (Turkish State Liquor and Tobacco Monopoly), was restored and revitalized in order to serve as the office building for an advertising agency group. While preserving the original character of the structure, a contemporary and adaptive function was added to the 3000-square-meter building.

The building of SALT Galata in Beyoğlu designed by the French Levantine architect Alexandre Vallaury housed the 19th century Imperial Ottoman Bank headquarters. A comprehensive restoration and redesign project was undertaken to experience new environments for living and working. The adaptively re-used building hosts conferences, exhibitions and other public programs. The restoration challenge was to gain functionality while revealing the original structure of the historic building.

Figure 1.2: SALT Galata, 2011.



Source: Bernardo Ricci Armani, http://ricci-armani.com/salt-galata/ [Accessed 1 September 2014]

While preserving the historic buildings as all the other buildings, an important concern is to minimize the operational expenses. Istanbul has many historic buildings, which build a specific extent in terms of their production techniques due to the climatic factors and their urban context. We learn much from the methods and practices of former architects and engineers. As Jane Jacobs (1961) claims, *"old ideas can sometimes use new buildings. New ideas must use old buildings."*

In order to achieve a sustainable city from a historic city as in Istanbul, there are green methods such as green building assessment systems. In order to apply green building certification systems to the existing historic buildings in Istanbul, smart and original approaches are necessary. The intent of this study is to provide well-reasoned and evidence-based strategies for sustainable preservation of historic buildings based on LEED certification system.

First of all, this study focuses on the potential advantages and problems of green adaptive re-use of historic buildings. After investigating the potential advantages and problems of green adaptive re-use of historic buildings in Istanbul, following question to be answered is that "how can we create effective and applicable strategies for green preservation of historic buildings in Istanbul?" This question constitutes the motivation of this research. In order to evaluate the practicability of sustainability, this research study identifies the main components of design and application process for LEED-based preservation in Istanbul.

As shown in the book *Historic Preservation and the Livable City* (2011), preservation is key in the creation of livable cities. The hypothesis suggested is that historic buildings, which have a significant degree of sustainability through their careful preservation and adaptive re-use, will reinforce city's cultural and urban identity. Moreover, the reinforcement of energy efficiency in buildings using sustainable-driven mitigation measures is key in providing a more sustainable and livable future in cities. The growing interest in environmental projects encourages architects to address environmental issues such as sustainability, re-use and recycling and to explore innovative design and reasonable architectural solutions for the built environment.

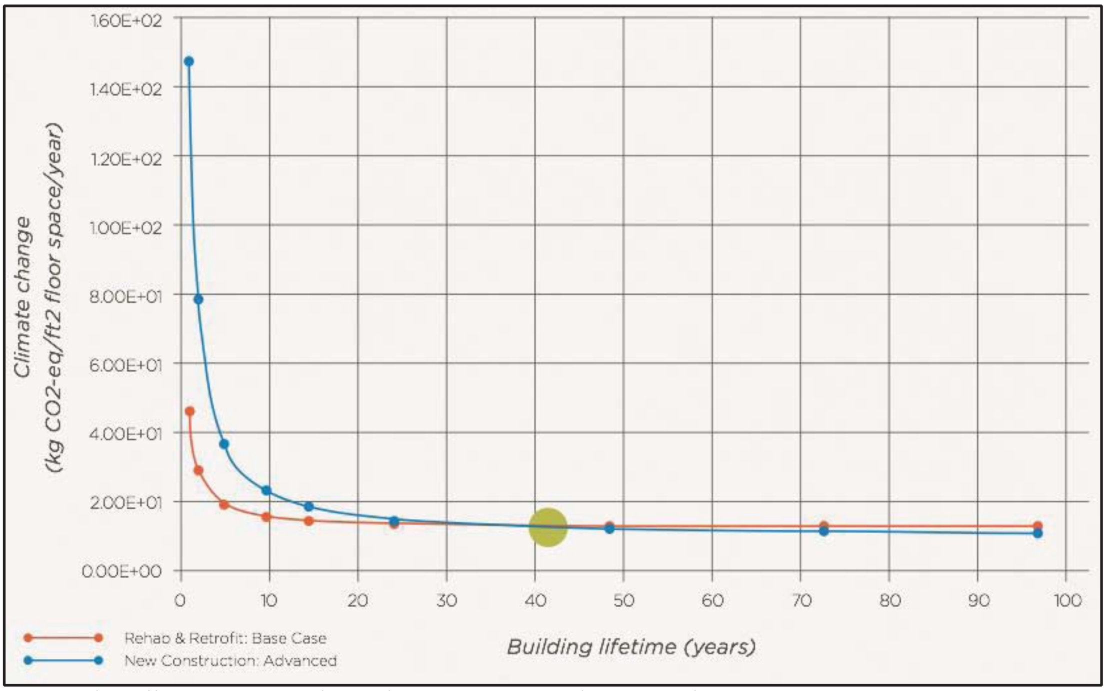
According to Schwartz and Raslan (2013), the increase in energy consumption leads to concern in relation to the political, environmental, economic and social inferences connected with it. Therefore, the green building sector supports environmentally responsible, energy- and resource-efficient building design with the aim of reducing greenhouse gas (GHG) emissions and other negative environmental impacts to ensure a more sustainable way of living. Much of the early emphasis has been on new building designs, but there is an increasing awareness of the importance of greening and retrofitting existing building stock. The goal is to minimize the overall energy consumption associated with existing and historic buildings with sustainable practices and green building techniques while at the same time maintaining the historic character and cultural significance. A small but significant proportion of existing buildings are considered to be historic buildings and the act of greening those buildings while preserving their historical and cultural value is an additional challenge that needs to be addressed.

Integrating renewable energy into building designs is a growing desire in developed countries. According to the Special Report (2013) of the Intergovernmental Panel on the "Renewable Energy Sources and Climate Change Mitigation", the building sector currently uses renewable energy to meet around 10 percent of its total consumer energy demand, excluding traditional biomass. In the future, renewable energy can be integrated more easily into urban environments when combined with energy efficient 'green building' designs. In rural areas in developing countries as it is in Turkey, many modest dwellings could benefit from the integration of renewable energy technologies. These technologies integrated into either new or existing building designs can enable the buildings to become net suppliers of electricity and heat.

Up to the present, studies on the climate change reductions that might be offered by re-using and retrofitting existing buildings rather than demolishing and replacing them with new constructions were limited. The Preservation Green Lab of the National Trust for Historic Preservation (2012) produced a groundbreaking study in which the building re-use and renovation offers a significant proportion of major environmental savings in contrast to demolition or new construction. According to the report named *The Greenest Building: Quantifying the Environmental Value of Building Reuse*, re-using buildings with an average level of energy performance as compared to more energy-efficient new construction will achieve larger GHG reductions.

The study uses life cycle assessment (LCA) method for quantification of the potential environmental benefits of retrofitting and re-using existing buildings and evaluation of the climate change impacts that were created during the construction process of new buildings over the time period of a 75-year life span. LCA is a method that investigates and valuates the financial, environmental and social influences of a product or service and in this case, it is an significant instrument because it helps to demonstrate if a product used in a green building is really green or not. With regard to the research results on climate change impacts, new buildings need 10 to 80 years to achieve the success of old buildings that have had energy-efficient retrofits. The graph below shows the point in a buildings lifetime or the payback period at which the environmental impacts associated with new construction equal those associated with renovation. It takes approximately 42 years for the efficient new building to overcome the climate change impacts that were expended during the construction process (Figure 3). Nevertheless, the act of re-using existing buildings alone is considered to be inadequate for reducing climate change emissions. Accordingly, the type and quantity of materials used in a re-use and renovation project play an important role in minimizing or even neutralizing the potential negative environmental, human health and resource impacts.

Figure 1.3: Climate change impacts by building lifetime for commercial office in Portland, 2012.



Source: http://www.preservationnation.org. [Accessed 2 September 2014]

Globalization and the rise of the transnational businesses have engendered awareness of sustainability and following this, to the request for universal methods of measuring the environmental performance of buildings and their materials with the common desire to live in a more environmentally friendly way. The intent of this study is to promote re-use of historic buildings in a sense that protects their historic character and materials as well as identify applicable and sustainable renovation strategies. So, this study deals with the sustainability evaluation of historic buildings in the scope of green building rating systems.

The Leadership in Energy and Environmental Design (LEED) building rating system introduced by the US Green Building Council (USGBC) in 2000 is a voluntary system to evaluate the environmental performance of a building over the entire life cycle. As this presents one of manifold independent systems for rating “green buildings”, it has been regarded as the leading green building rating system. Scofield (2009) claims that, since its conception, the prevalent hypothesis has been that a LEED-certified building is an energy-efficient building.

The UK-developed Building Research Establishment Environmental Assessment Method (BREEAM) launched by the British Research Establishment (BRE) in 1990 is the other prominent environmental assessment method and rating system for buildings. These green building certification systems are discussed through their different features in evaluating sustainability of the built environment. In order to choose the most applicable one for the study, it is essential to comprehend the discriminating schemes from the viewpoint of their assessment methods, scopes, and performance criteria as credit scales. There are several studies (Lee, 2008, Patxi, 2008, Asdrubali, 2008 and Lamberto, 2008) performed to benchmark the popular building environmental schemes that are currently in use. While LEED focuses in reducing annual expenses on energy in buildings and suits to climates where mechanical ventilation is used as well as places where car driving is encouraged, BREEAM’s major concern is decreasing CO_2 emissions resulted from energy use in buildings and consequently it is considered to be more promotive of facilities that reinforce pedestrian and cycle-based forms of transport. This study will be based on LEED certification system as the requirements of LEED necessitate major restorations of buildings. This study deals with the green restoration of a historic building in Istanbul.

1.1 METHODOLOGY

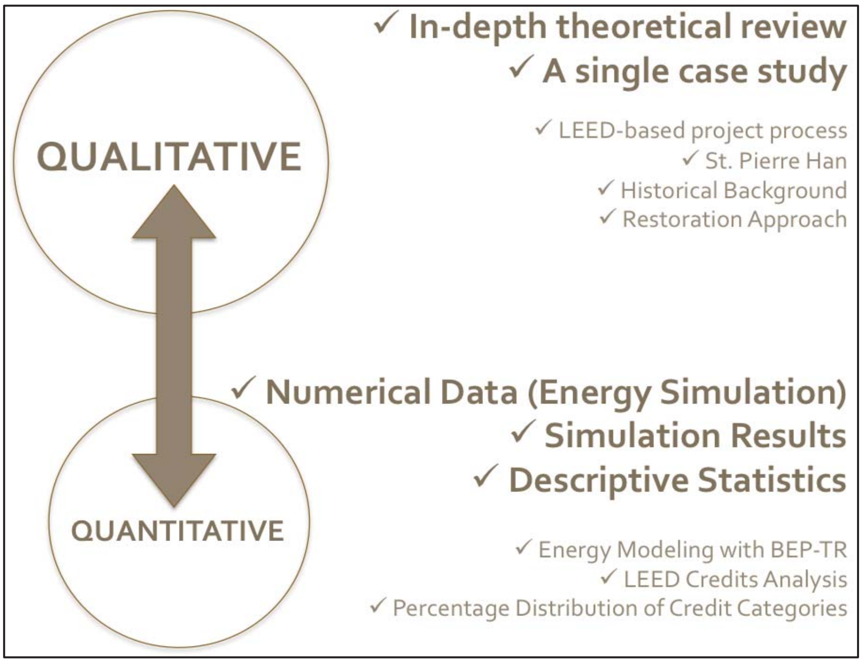
The study employs mixed-method strategies as its methodological framework. This is based on primarily qualitative and complementary quantitative research techniques and methods. In order to create effective and applicable strategies for green preservation of historic buildings in-depth theoretical review and a case study are essential. In order to support the case study, a computational simulation study is also carried out.

The main problem in this research is the concept and application of sustainability. This is a research by design followed by the analysis of the building envelope and the building itself and evaluation of the results in terms of sustainability. It is about building physics and green building certification systems, especially embracing the LEED. First of all, it is important to discover, if the requirements of LEED or BREEAM necessitate historical buildings or not. A comparison between the two rating systems leads to the choice of the relevant assessment procedure. LEED 2009 for New Construction and Major Renovations addresses design and construction activities for both new buildings and major renovations of existing buildings. In this case, the requirements of LEED-NC necessitate major HVAC renovation, significant envelope modifications and major interior rehabilitation. As a result, LEED-NC is the appropriate rating system for this thesis.

The case study building selected for the study is the 400-year-old St. Pierre Han, located in the Galata district of Istanbul. It is a representative building and considered to be typical of the area. The historical development and the current situation of the *han* building are to be found in the fourth chapter. The historic background research is obligatory for a comprehensive analysis. It is an inspiring building to re-create culture and therefore it will adaptively re-used as a cultural arts center by the Bahçeşehir University. Further research and analysis on the existent building is held, so that the potential sustainability properties may be discovered. The archaic construction methods and used materials may be helpful to recommend further restoration suggestions.

In order to predict energy consumption and award relevant energy performance credits of a building, computer-based Building Performance Simulation tools (BPS) are used. These computer-based methods may be helpful for an extensive research. The most widely used BPS tools are Tas, EnergyPlus and IES. Since 2009, Turkey also developed a national calculation methodology, BEP-TR, and its software to simulate the building's energy performance. In this study, BEP-TR is preferred as the tool to energy modeling and measure the energy performance of the case study building. BEP-TR is based on simple hourly method, which is a semi-dynamic simulation method. It can demonstrate building's hourly thermal behavior in a realistic way by using hourly meteorological data and hourly schedules for occupancy and lighting power. In comparison to monthly or seasonal method, simple hourly method gives more precise results, particularly in transition periods in which meteorological data show significant changes in time intervals much smaller than a whole month or season. The energy consumption of St. Pierre Han is determined by carrying out thermal analysis by BEP-TR simulation program, so the thermo physical properties of constructional components are evaluated. With the support of the computer-based tools, advices are given in order to earn more credits for the building towards LEED rating system.

Table 1.1: Methodology of the thesis



Source: Edited by Dila Vural.

1.2 LITERATURE REVIEW

A vast literature on green building and sustainable architecture has accumulated over the past decade. In most general terms, green building is understood as the Office of the Federal Environment Executive (OFEE) defines (Kubba, 2012):

> *The practice of (1) increasing the efficiency with which buildings and their sites use energy, water, and materials, and (2) reducing building impacts on human health and the environment, through better siting, design, construction, operation, maintenance, and removal—the complete building life cycle.*

Dr. Kubba's Handbook of Green Building Design, and Construction with numerous practical project advice and proof sources of the benefits of green buildings covers all of the key elements of successfully practicing sustainable architecture from concept to operation.

A respectable body of literature has also been generated investigating the sustainable building certification systems each with various scopes of environmental impact, categories of interest and strategies for analysis and decision-making processes (Roderick, McEwan, Wheatley & Alonso, 2009; Saunders, 2008; Fenner & Ryce, 2007; Schwarty & Raslan, 2013). The energy performance of a building and the related energy rating achieved are highly conditional on the assessment method applied. In the case of LEED-certified commercial buildings, Scofield (2009) provides a detailed analysis and discusses that LEED-certified office buildings in total are not using less energy than their non-LEED counterparts. Moreover, a re-analysis of data supplied by the New Buildings Institute and the US Green Buildings Council on measured energy considering 100 LEED-certified commercial and institutional buildings shows that the measured energy performance of LEED buildings had minor interrelation with certification degree of the building, or the number of energy credits gained at design phase of the building (Newsham, Mancini & Birt, 2009). However, these analyses may be repeated in order to use extended data histories from a broader sample of green buildings. In contrast to these, other studies examine the benefits of rating systems and document the advantages of green buildings in the case of 30 percent energy savings, 35 percent carbon savings, 30-50 percent water savings, and 50-90 percent waste cost savings (Campagna, 2012; Burt, 2011).

While the literature on certification systems has diversified considerably over the past decade, the centre of gravity from the point of theoretical and empirical work still lies within Europe and North America. Most of our foundational knowledge on green building certification systems is reproduced from the experiences of the major countries of the West. In order to enrich our understanding of green buildings, case study based research located in Turkey may be necessary as well as the application of the executed study.

As a reference case study, a 19th century design building, Baylo Suites in Galata, is the first renovation project in Turkey with a Silver LEED-NC and Major Renovations certificate (Figure 1.4). This is a renovation project in priority of history, culture and environment. Altensis managed the LEED evaluation process of this building as the first sustainability management company in Turkey that provides service on this area. As Turkey’s leading sustainability consultancy company in building industry, Altensis provides the LEED consulting and management services in order to fulfill the requirements of LEED certification system. According to the LEED AP’s, the first step in this project was to behave consciously. The green attempts led to a small increase in costs, which is around five percent. The wooden window frames were preserved and double-glazing was used in order to save energy and ensure a high internal air quality. The self-clearing, zero-VOC and non-polluting house paint was used to decrease the operational expenses as it protects human health. The green roof helped to achieve more credits for the LEED-certification. Not only outer side, but also the inner side of the building was preserved during the renovation process. The most important renovation criteria were to stay loyal to the spirit of the streets in Galata and its population considering the conservation of historical and cultural issues. In addition to this, the criteria of the LEED evaluation system were to minimize the negative environmental impacts and fulfill the requirements of the building with current technological solutions.

Figure 1.4: Baylo Suites in Galata, before and after the renovation process.

Source: EkoYapı, No.4, March-April 2011, pp.84-87. http://nurdanorhan.com. [Accessed 2 March 2014]

The study about the LEED Rating Systems for Historical Restorations (Stephens & Siddiqi, 2013) published in the 49th ASC Annual International Conference Proceedings discusses about the significance of historic preservation and LEED. This research paper lays emphasize on the sustainable design projects that involve historic preservation projects because it is proven that new green buildings consume more energy than buildings that are already being used and it costs less to take an existing building and renovate it instead of to build a new one (Laskow, 2012). As the LEED AP Carl Elefante (2007) phrases, *"the greenest building is the one that is already built."* Carroon's Sustainable Preservation: Greening Existing Buildings (2010) is a guide to green strategies for preservation and adaptive re-use. As a leading preservation architect, Carroon explores the power of adaptive re-use as a green strategy and a way to move toward sustainability. The book explains how an icon such as H.H. Richardson's Trinity Church in Boston can become green and it presents fifty case studies of projects, which may play a leading role in this study.

In her thesis, Ünver (2006) evaluates the Keklik Street and its Surrounding Conservation and Development Project with respect to sustainability principle of Cultural Heritage Management emphasizing the contribution of the sustainability principle of the management approach and its instruments to the heritage conservation process, but the methodology and the aim of the executed study is completely different than this study. There are examples of historic buildings (Empire State Building, Colorado State Capitol, U.S. Treasury Building) around the world that are certified as green buildings, but this is yet not the case in Turkey. Various research and study papers are written about sustainability and the assessment methods as well as rating systems, but the preservation and renovation of historic buildings are not mentioned in detail, especially in Turkey.

A thesis about ‘sustainability evaluation of an office building in Istanbul in the scope of LEED certification system’ was written by İrem Saka in 2011. The difference between this research paper and the former is that they are analyzing different kinds of buildings with different methodologies. The criteria for the evaluation are different, but these case studies are both applicable and they are preliminary for further studies on green building certification systems and renovation strategies in Turkey.

This research paper is a leading one to serve for a later research giving a sense and showing methods for a sustainable and energy efficient built environment. Regarding this study, the methodology may be applied to other types of historic buildings. Moreover, the existing environmental standards for buildings around the world including SEEB-TR from Turkey, CASBEE from Japan, BREEAM from the UK and Green Star from Australia may be developed for further specific sustainable preservation and renovation strategies for the existing historic buildings.

This work continues and expands the research in the field of sustainable historic preservation and green renovation exploring an as yet unexamined aspect. As a result, it is a preliminary investigation into the existence of any such phenomena.

1.3 SCOPE OF STUDY

The present study is divided into four chapters and a conclusion part. The first part includes the introduction, literature review and the methodology of the study. The introduction part describes the research problem and gives insight about the importance, drivers and motivators of the research study, states the objectives, the research questions, research hypotheses and sub-hypotheses for the study. In addition, the existing literature that bears on the stated problem is critically reviewed and the employed research methodologies for the study are described. The second chapter investigates the notion of sustainability, clarifies the origin and progress of the sustainability concept, presents the current studies on green buildings, the challenges for greening existing buildings, the benefits of green retrofits and the widely accepted green building rating and certification systems. In order to choose the most applicable green building assessment method and rating system for the study, the discriminating schemes regarding their assessment methods, scopes, and performance criteria as credit scales are analyzed in detail. As a result, this study will be based on LEED certification system as the requirements of LEED necessitate major restorations of buildings. In the third chapter, the minimum program requirements and the credit categories of LEED 2009 for New Construction and Major Renovations are thoroughly scanned and also the certification process is described. The fourth chapter evaluates the case-study building St. Pierre Han[1] in Galata in the scope of LEED rating and certification system and aims to provide the buildings energy performance in order to suggest a degree of certification. In the conclusion, the importance of green retrofitting for existing historic buildings is examined with the evaluation results of the case study building and some suggestions for the certification process and the future studies are given.

[1] The Turkish word *han* preffered to use in the thesis can be translated as a type of “motel” where medieval merchants would stay and also conduct business; similar to a caravanserai or a tranders’ inn.

2. SUSTAINABILITY

The notions of sustainability and sustainable development were first introduced in the 1970s by Dr. Gro Harlem Brundtland and in 1987 the World Commission on Environment and Development published a report with the title “Our Common Future”, which formally defines these terms as (Brundtland, 1987):

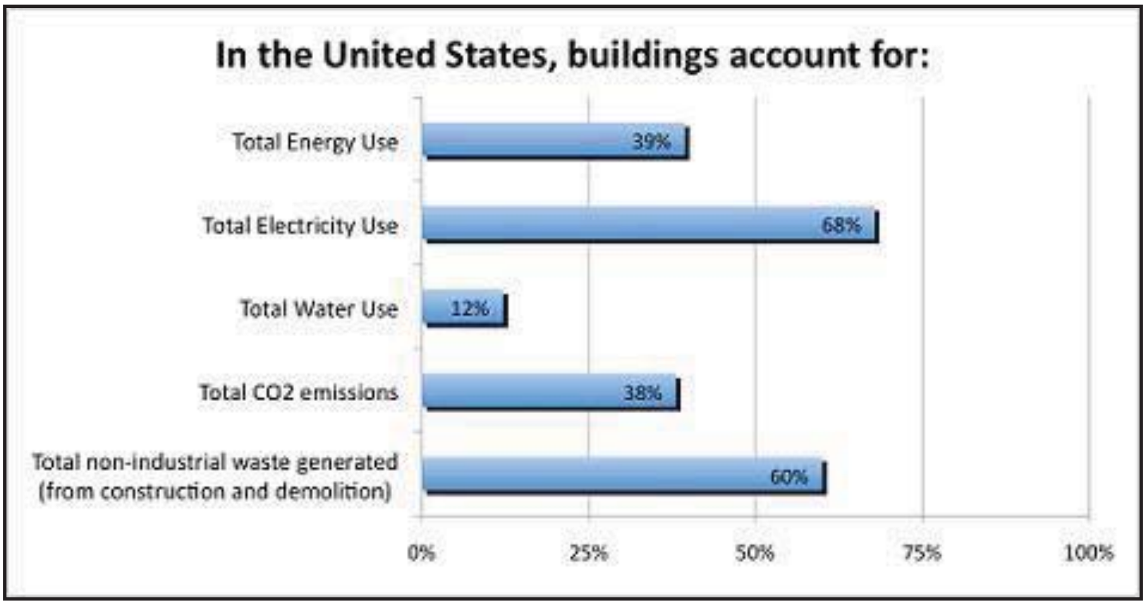
> *Humanity has the ability to make development sustainable to ensure that it meets the needs of the present without compromising the ability of future generations to meet their own needs. The concept of sustainable development does imply limits - not absolute limits but limitations imposed by the present state of technology and social organization on environmental resources and by the ability of the biosphere to absorb the effects of human activities. But technology and social organization can be both managed and improved to make way for a new era of economic growth. The Commission believes that widespread poverty is no longer inevitable. Poverty is not only an evil in itself, but sustainable development requires meeting the basic needs of all and extending to all the opportunity to fulfill their aspirations for a better life. A world in which poverty is endemic will always be prone to ecological and other catastrophes.*

Rapid industrialization and urbanization activities due to industrial revolution beginning with the 19^{th} century and following developments in technology increased the need for settlement by virtue of population growth. The rapid increase in building stock had negative environmental effects. The emerging developments accelerated understanding the significance of ecology science and the notion of sustainable development. Social, environmental and economical sustainability concepts ensued as a consequence of studies executed by international circles for the solution of environmental and social problems. As explained by Brundtland Commission, sustainability is an interdisciplinary term, which has both ecologic and economic returns. Also, as mentioned in the report, the efforts for attracting notice on this term aim to provide the sustainability of resources in order to guarantee meeting the needs of next generations.

Additionally, the two major oil crises started in 1970s resulted with the concern that conservation of non-renewable energy sources is indispensable. As the statement made by European Union (EU), buildings have a proportion of 40 percent of total energy consumption all over the world and the proportion tends to be higher for developing countries. Consequently, this large percentage became the major indicator of significant reductions through energy consuming processes in buildings, especially for heating and cooling. Because of the problem that natural energy resources are on the point of exhausting, energy efficiency is key in preventing rapid resource consumption and to this respect, the depletion of natural balance.

Recently, sustainability has come to be regarded as a fundamental subject in architecture, engineering and construction industry, since climate change, energy use, water use, use of raw materials, waste generation and other factors are ever-growing concerns throughout the world. The amounts of energy consumption and GHG emissions from buildings have been disconcerting as the population and the economy continue to expand.

Figure 2.1: EPA, impacts of buildings in the US on the environment, 2004.



Source: http://www.wbdg.org/design/sustainable.php. [Accessed 2 September 2014]

In terms of raw material extraction and land use, the construction industry has the highest impact of any sector. According to EPA, buildings were in charge of 38.9 percent of total U.S. energy consumption in 2005, while commercial buildings accounted for the 46.3 percent of that total (Figure 2.1). On the other hand, buildings in the United States contribute 38.9 percent of the nation's total carbon dioxide emissions and use 13 percent of the total water consumed per day. As a result, the building sector aims to increase the number of green buildings in order to face increasing challenges to meet the new and renovated demands for facilities that are sustainable, green, healthy and productive while reducing the negative impacts of buildings on the environment and natural resources.

2.1 SUSTAINABLE BUILDINGS

Over the past years, there is a rapid increase in both awareness and concern about the impacts of buildings on the global environment. The concern is first of all about the health of the living environment within and around buildings and secondly about the impact of the energy and resource use in buildings on the global environment. Since the impact of buildings on the ecological problems occurred on the world is about 80 percent, the functioning of the sustainability concepts is important. The green building movement is a paradigm shift that emerged to minimize the negative environmental effects of buildings, to bring significant economic and social benefits and to make progress in the building construction process.

Considering sustainable buildings in the framework of ecology and human health, not only the selection of appropriate technologies, but also the choice of proper materials used in the building are key in conservation of resources and enabling a healthy environment, as buildings are part of the cycle. The materials selected in a sustainable building are preferably obtained from local sources, that has low embodied energy and no production wastes and are easy to maintain, economic, durable, reusable and recyclable.

Green buildings are defined as resource-efficient and environmentally responsible throughout their life cycle from design to construction, operation, maintenance, renovation and deconstruction. The number of new constructed buildings with a green building certificate is increasing expeditiously. Meanwhile, green buildings represent a small subset of existing building stock.

The founder and the author of *The Original Green* (2010), Stephen A. Mouzon, identifies the characteristics of sustainable buildings as nourishable, accessible, serviceable, securable, lovable, durable, adaptable and frugal. He mentions the sustainability of heritage buildings in terms of how people designed in order to survive before the Thermostat age and how buildings kept people warm in an era before petrol and cool before air conditioning was originated. He also points out that old technologies and design criteria are less complex, easier to maintain and adjust than the current world of green and sustainable design and technology. As an instance, Weber Thompson's Terry Thomas Building in Seattle is designed with simple methods that were known before Thermostat age.

The Terry Thomas (2005) is a highly sustainable; LEED Gold for Core and Shell certified commercial building by Weber Thompson Architects located in Seattle. It is built without central air conditioning, with natural light and ventilation, and uses 30 percent less energy by utilizing the time-tested strategies of former architects. According to the project architect, Weber Thompson (2007), sustainable building is defined as:

> *A place that promotes a healthier environment by using energy, water and other natural resources more efficiently, which, in turn, will reduce our impact on the environment. A sustainable building uses design and technology that works with nature. It promotes a sense of community, a sense of place.*

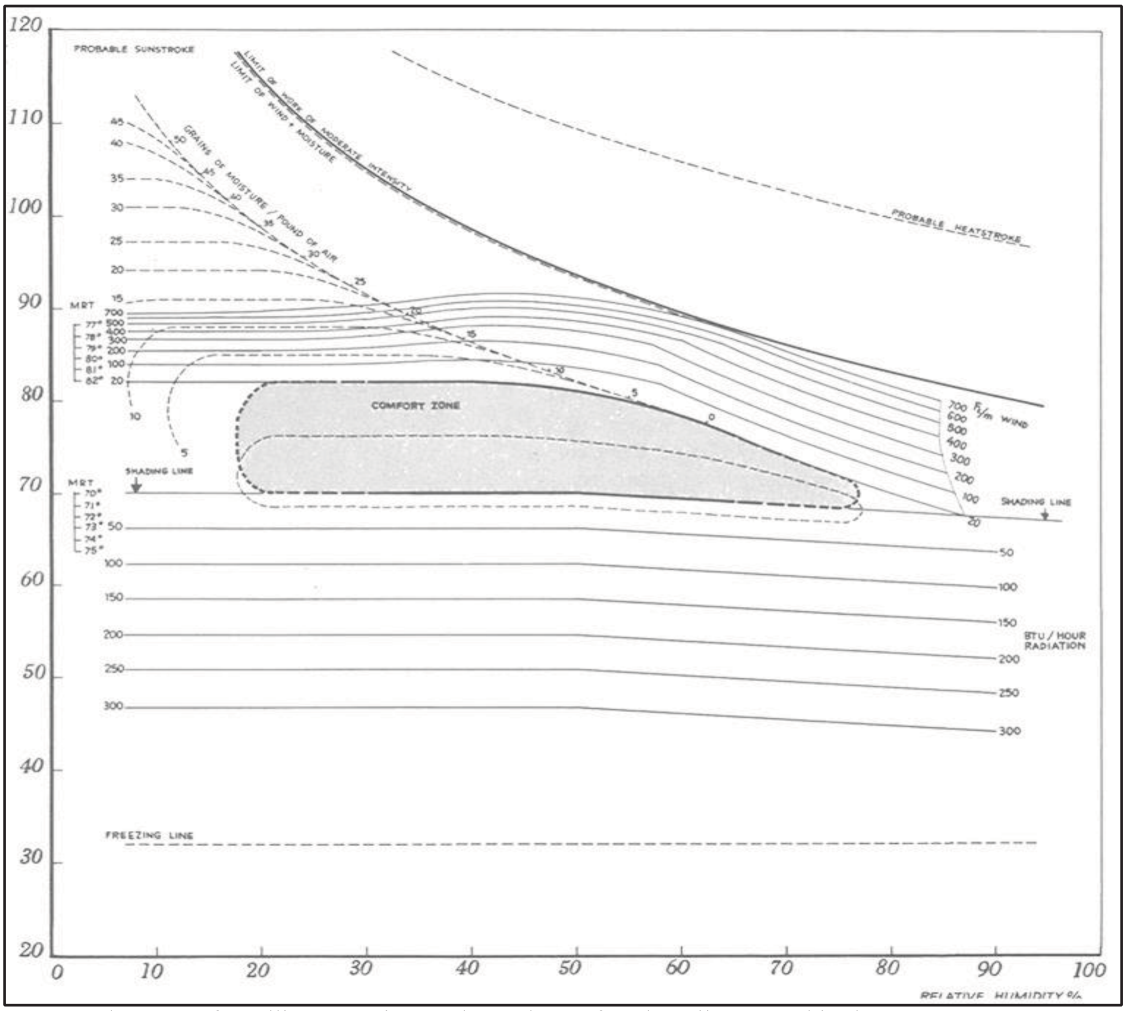
Figure 2.2: The Terry Thomas Building in Seattle, 2005.

Source: Weber Thompson, http://www.weberthompson.com. [Accessed 13 October 2014]

Historic buildings have a vital role regarding their traditional construction systems that reflect regional culture lasting for centuries in terms of planning and also embody sustainable design criteria with their structures that are suitable to recycle to nature, can get warm and cold without any need to additional measures and provide comfortable indoors since they are constructed from natural materials that correspond to the climatic and geographic structure of its region. The drawing (Figure 2.3) from Victor Olgyay's 1963 book *Design with Climate* shows an expanded comfort zone of temperature, humidity and air movement where people are comfortable. The old buildings depended on this comfort range in opposition to the mechanical engineers today that support a two-degree spread at that point. The original and traditional ways of building and living is the key to sustainability. Learning from what people have been doing for generations may support the idea that historic buildings are originally green.

Today, green concepts are moving towards the mainstream. "*As people move into the cities and restore old houses, more people feel comfortable moving back to the city to restore more houses"* (Lubeck, 2010). Preservation is synonymous with sustainability as Mouzon (2009) mentions, *"preservation is the act of ongoing sustainability."* An historic building proves its sustainability by existing for a very long time. As a result of this determination, adaptive re-use of historic buildings needs to be developed very quickly.

Figure 2.3: Victor Olgyay's comfort zone for moderate climates, 1963.



Source: Elements of Intelligent Design – Thermal Comfort, http://www.archinology.com. [Accessed 10 November 2014]

2.2 RATIONALE & CHALLENGES FOR GREENING EXISTING BUILDINGS

Why pay almost as much for an old building as for a new one? First of all, green retrofitting of historic buildings is a sustainable practice. Green retrofits have benefits in means of health and comfort, positive economic returns and the reduction of climate change impacts. Environmental impact of re-using existing buildings is less than creating new efficient buildings. Based on this, existing buildings reduce climate impact and energy consumption over the newly built. The infrastructure is already in place. Historic preservation has environmental, cultural and economic benefits. Historic features can be repaired and restored for higher efficiency. In general, historic buildings are energy efficient from their inherent characteristics such as their use of natural light and ventilation, durable materials and spatial relationships.

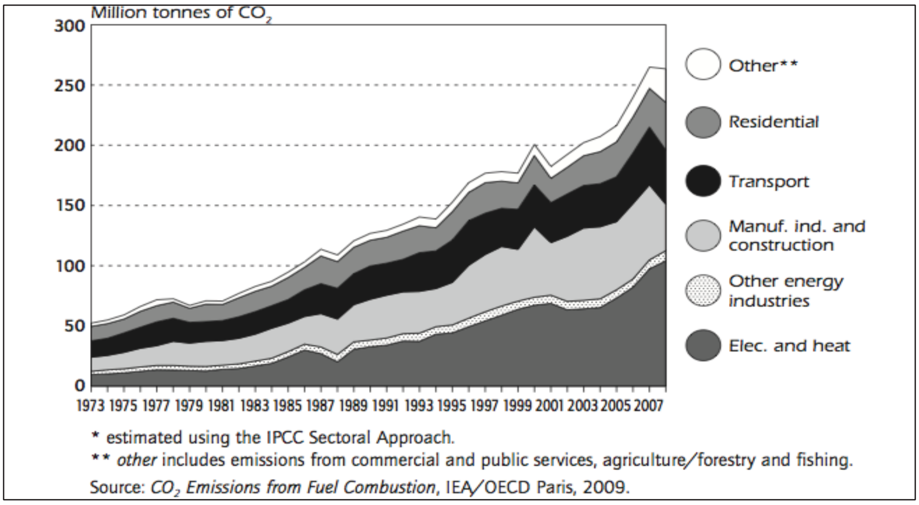
Many existing buildings are well designed and already energy efficient. An existing building conserves embodied energy and human capital. The embodied energy is defined as the amount of already invested energy that has been expended in the procurement, manufacture and transport of materials and the construction process itself. They were built with superior craftsmanship and materials that support a long physical life. An important point to mention is also that an existing building does not create waste.

As Stephen Mouzon (2010) denotes, *"preservation is the act of ongoing sustainability."* Preserving existing historic buildings is an environmentally responsible practice. Buildings which are constructed by traditional construction systems reserve sustainable design criteria with the features that;

a. are easy to recycle to nature,
b. can get warm and cold without any need to additional precautions,
c. provide comfortable indoors since they are constructed from natural materials that accommodate the climatic and geographic structure of its region.

The grim reality is that the vast majority of the building stock is not green. The process of retrofitting is basic to improve the energy efficiency of the existing buildings whether by installing more energy efficient facilities or by increasing the quantity of insulation in a building. According to the report of the United Nations Environment Program, 30 to 40 percent of all primary energy produced all over the world is used in the building sector. In addition to this, the International Energy Agency estimated that the existing buildings are in charge of more than 40 percent of the world's total primary energy consumption and of 24 percent of global CO_2 emissions. The green building sector supports environmentally responsible and resource efficient building design with the aim of reducing GHG emissions and other negative environmental impacts. As a British architectural journalist and the chairman of the centre for London's built environment New London Architecture, Peter Murray (2014) suggests, *"Breathing life back into town centers and increasing the performance of the existing building stock"* helps reducing GHG emissions in the cities. The historic buildings are in a special case by their higher site coverage and their proximity to public transport. By keeping the urban area compact, reliance on private cars is reduced, as is the need for costly new infrastructure. As a result, cities can become more ecological. The aim of retrofitting is to develop the energy performance of existing buildings. In Turkey, too, major contributors to CO_2 emissions are mostly tied to the building sector (Figure 2.4).

Figure 2.4: CO_2 emissions by sector, 1973 to 2008 in Turkey.



*Source: h*ttp://www.iea.org. [Accessed 2 September 2014]

Pre-industrial buildings are accounted for being green and sustainable because of the reason that climatic factors were the primary consideration of their architects during their construction period and also mechanical systems were not yet discovered. They were traditionally designed with many features that responded both to climate and site as a process of adaptation. So, these old structures are samples of vernacular buildings, which are well adapted to their particular site and local climate. Old buildings had to rely on natural light and ventilation before the advent of modern heating, air-conditioning and lighting systems. They have a high thermal mass, usually constructed out of masonry, in order to provide passive heating and cooling.

Meanwhile, green retrofitting preserves our legacy and helps for the revival and reconstruction of the city center. Preserving historic buildings is essential to understand our nation's heritage. We learn much from the methods and practices of those who came before us. Designers do not work on a tabula rasa, but on an existing platform, which do former architects plan. The existing conditions are convenient for intervening, inserting, interrupting or interceding. The preservation and adaptive re-use of existing historic buildings creates a sense of place and serves for the collective memory. Furthermore, preservation and adaptive re-use of existing historic buildings serve for the heritage tourism by keeping our nation's history and culture alive. These projects can also be enjoyed by the future generations.

An economy that is more labor intensive and less materials intensive is a greener economy (Moe, 2009). As key element in sustainable development, the green preservation and adaptive re-use of existing buildings present excellent opportunities to reduce the energy consumption and CO_2 emissions. Because of this reason, interaction between sustainability and the preservation of heritage buildings has increased within the past decade. So, the strategy to achieve sustainable development should be based around greening the existing building stock rather than building new green buildings.

Concerning the economics of green renovations, the first released research study focused on this topic indicates that investments in the sustainability of commercial buildings are economically viable (Kok, Miller & Morris, 2012). In addition, it is estimated that there is a significant rental premium for LEED-certified buildings versus non-LEED buildings. Green certifications increase the value of the real estate and as the catchphrase highlights, *"Green doesn't cost, it pays!"* Following this positive correlation between green buildings and their rents, the certification of existing building renovations is growing in the marketplace and unexpectedly outpacing new construction certification rates.

2.3 GREEN BUILDINGS RATING AND CERTIFICATION SYSTEMS

One of the major issues for our developing world is the subject of sustainable development. The most significant constituents of sustainable development are the building construction and operation, which have irreversible environmental impacts in means of the consumption of raw materials, energy and water, atmospheric emissions and waste generation. Green building certification systems have emerged in order to control and evaluate the environmental impacts of buildings and assess their performance along in a wide range of environmental considerations. Green buildings' purpose is to use land and energy resourcefully, save water and other natural resources, increase indoor and outdoor air quality, and utilize recycled and renewable materials.

The major green building rating systems that are widely used in the world are the BREEAM in UK and LEED in USA. Regarding their credibility, integrity and the increasing recognition of green building design and construction systems, these systems get more valuable all over the world. These building assessment systems also lead to the awareness of sustainable materials, massive environmental effects of materials throughout the life cycle of a building. These tools have some distinctive properties in which BREEAM schemes focus on the type of building as LEED focuses on the buildings being new constructed or existing.

In 2007, only a building was certified as a green building in Turkey. Today, 69 buildings are certified and more than 200 buildings are applicant for a green building certificate. Increasing knowledge of these systems contributed to the awareness of the need for a local green building assessment system regarding Turkey's state-of-market, technology and legal conditions. Turkey Green Building Association (CEDBIK) is becoming an emerging member of World Green Building Council (WGBC) and it plays a significant role in arousing interest in environmentally friendly buildings in Turkey. SEEB-TR (Sustainable Energy Efficient Buildings) is the first green building assessment system in Turkey. SEEB-TR is a great progress in green building industry as Turkey's own national environmental assessment method.

Green building rating systems have become a powerful marketing tool and facilitate green washing strategies that don't necessarily support sustainable development. The certification process needs transparency in actions and behaviors. LEED is a tool to get the name "green building", but how fair or fact-based is the process or does it really reflect the reality? The quantity shouldn't override the quality. LEED shouldn't become a pure marketing tool. Relevant to this issue, YEM conducted EkoDesign Conference for the 7th time with the theme transparency and discussed this topic with architects and related authorities.

This study will be based on LEED rating and certification system as the requirements of LEED necessitate major renovations of historic buildings.

3. UNDERSTANDING THE BUILDING DESIGN + CONSTRUCTION LEED 2009 RATING SYSTEMS

After the establishment of the U.S. Green Building Council (USGBC) in 1993, the organization's members delegated a committee consisting of architects, real estate agents, a building owner, a lawyer, an environmentalist and industry representatives to search for a system to define and quantify green buildings. As a result of this cross section of people and professions, the sustainable building industry gained a universal green building rating and certification system.

The first LEED Pilot Project Program was introduced at the USGBC Membership Summit in August 1998 as LEED Version 1.0. After large-scaled modifications, LEED Green Building Rating System Version 2.0 was publicized in March 2000. LEED Version 2.1 in 2002 and LEED Version 2.2 in 2005 followed the older versions. Due to the fact that green building sector is growing rapidly and new technologies as well as products are being launched daily to the marketplace, the program had to bring new initiatives. Sustainable efficiency of innovative designs, constructions and practices also diversify the scope of the program with the aim of ensuring a more healthful, durable, cost efficient and environmental living. So, LEED rating system is not only devoted to building operational and maintenance subject (LEED for Existing Buildings: Operational and Maintenance), but also addresses alternative project development and delivery processes regarding their building typologies, sectors and project scopes: LEED for Core & Shell, LEED for New Construction and Major Renovations, LEED for Schools, LEED for Neighborhood Development, LEED for Retail, LEED for Healthcare, LEED for Homes, and LEED for Commercial Interiors.

In order to understand the rating and certification process of LEED, the relevant system for this research study, the LEED for New Construction and Major Renovations and its credit categories with their concepts are examined in detail.

3.1 LEED FOR NEW CONSTRUCTION & MAJOR RENOVATIONS

LEED for New Construction and Major Renovations addresses six topics with different percentages per section. The performance standards set by the system measure and certify the design and construction of commercial, institutional buildings and also high-rise residential buildings of all sizes, both public and private.

As a first step to the LEED assessment and certification process, the project should be registered with the USGBC by submitting an application along with registration fees. The project team, general project details, project program data and the pilot LEED checklist should be reported in the registration form. The project team is responsible for the documentation essential for the assessment, but leaving a LEED AP in charge as part of the design team brings a credit.

3.2 MINIMUM PROGRAM REQUIREMENTS

The first step for the rating is to identify the minimum program requirements of LEED-NC. Initially, the compliance of the project with environmental laws is to be proven. Afterwards, the building should be complete and permanent with a reasonable site boundary, a minimum floor area, with minimum occupancy rates and provide the minimum building to site area ratio. The building should be minimum 93 m^2, the minimum building to site area ratio should be two percent and at least a person should be living in the project building. A building without occupancy is not able to be LEED certified. Last but not least, the building needs to share energy and water use data with the USGBC for at least five years. After these minimum program requirements are fulfilled, the rating with the credit categories can be applied to the project building. If one of these requirements is not met, the building cannot be rated or certified.

3.3 CREDIT CATEGORIES

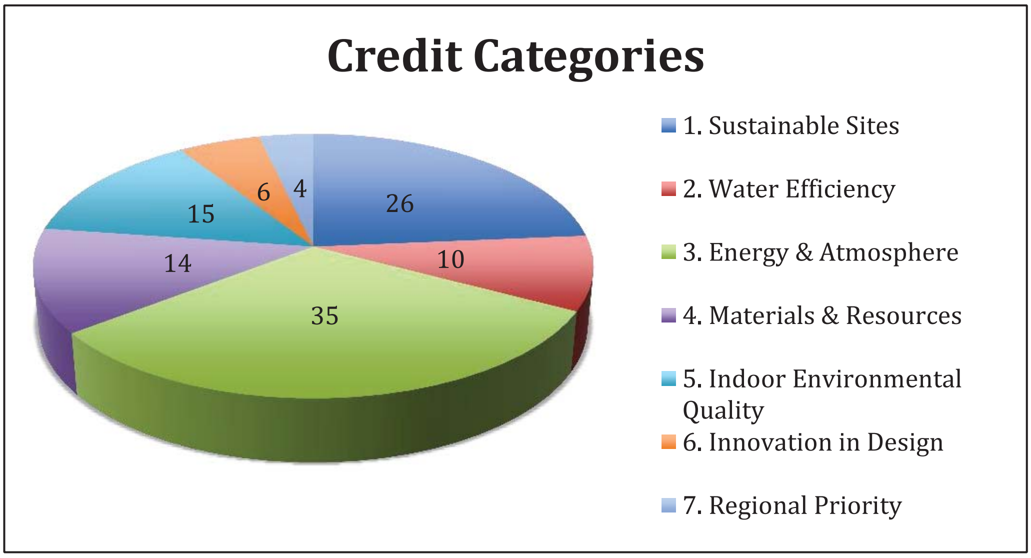
LEED rating system has 110 credits in total. Credit categories consist of sustainable sites, water efficiency, energy and atmosphere, materials and resources, indoor environmental quality, innovation in design and regional priority. In sub-titles, these seven categories are explained in detail (Tables 3.1). In the fourth chapter, the case study building, St. Pierre Han, is evaluated according to these seven credit categories.

Table 3.1: LEED-NC credit categories analysis

Credit Categories	Possible Points
1. Sustainable Sites	26
2. Water Efficiency	10
3. Energy & Atmosphere	35
4. Materials & Resources	14
5. Indoor Environmental Quality	15
6. Innovation in Design	6
7. Regional Priority	4
Total Credit Points:	**110**

Source: Edited by Dila Vural.

Table 3.2: Percentage distribution of LEED-NC credit categories



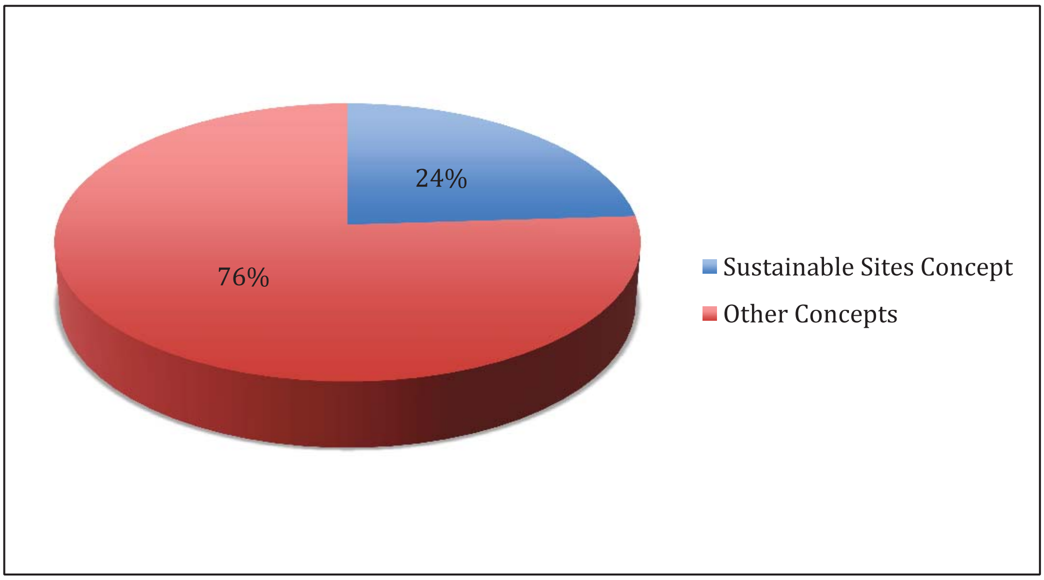
Source: Edited by Dila Vural.

3.3.1 Sustainable Sites Concepts

In sustainable sites concept, 26 possible credit points can be earned, but the building can only be evaluated if the prerequisite of this credit category is fulfilled. The single prerequisite is to prevent construction activity pollution in order to prevent polluting air with dust and particulate matter. The project team needs to implement an erosion and sedimentation control plan during construction. In this manner, loss of soil through storm water runoff or wind erosion, as sedimentation of storm sewer or receiving streams can be prevented. After the prerequisite is fulfilled, there are 14 credit categories in this concept to earn points with the aim to preserve habitat and reduce negative environmental impacts of the building.

Site design and management is the first step to get points from this credit category. Location and planning is the second important sub-heading in this concept in order to earn more credit points.

Table 3.3: Percentage distribution of sustainable sites credit category



Source: Edited by Dila Vural.

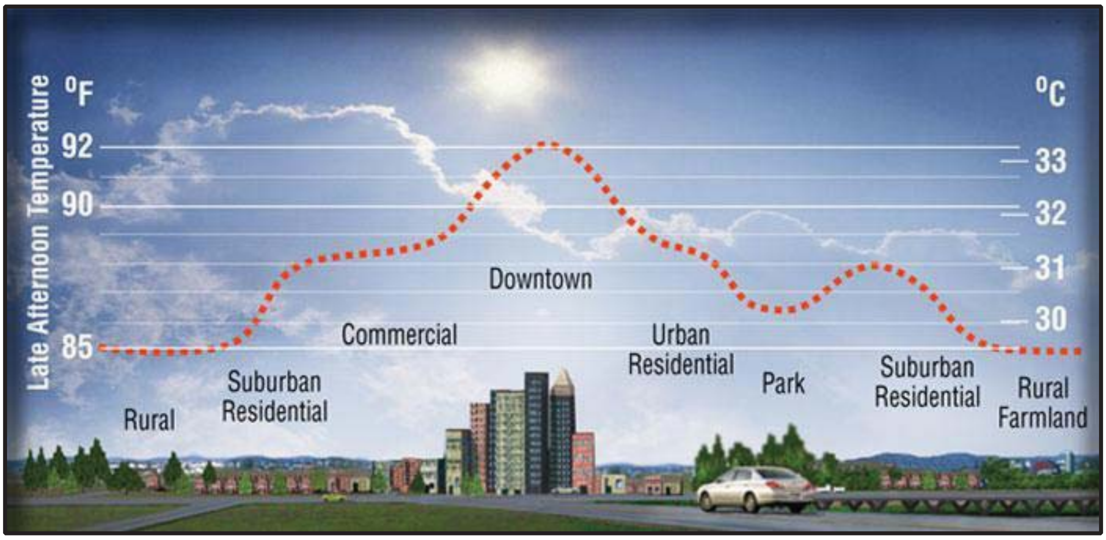
3.3.1.1 Site design & management

Sustainable sites concept aims to select a previously developed site in order to protect surface waters and aquatic ecosystems, and to preserve or restore habitat and wetlands. The selected site must either be a greenfield or a previously developed site and a credit point is earnable if the site area is restored with native or adapted vegetation. LEED aims to maximize site open space by minimum 25 percent and gives a credit point if open space equal to 20 percent of site.

Quantity and quality controls each with one credit point within the stormwater design help rainwater management and prevent increased stormwater runoff due to impervious surfaces like roofs and parking lots. To earn this credit, in case of existing imperviousness of 50 percent or less, post-development must discharge less than pre-development or receiving stream channels must be protected from excess erosion. In case of existing imperviousness greater than 50 percent, 25 percent decrease in volume of runoff must be achieved from 2-year, 24-hour design storm. Green roofs are favorable in these cases, but the most advantageous option is to simply encourage natural infiltration of stormwater into the ground. Within the quality control of stormwater, the first option is to capture and treat 90 percent of average annual stormwater runoff and remove 80 percent of total suspended solids or the second option is to provide in-field performance data that confirms acceptable protocols for best management practices monitoring.

According to LEED, heat islands are defined as thermal gradient differences among developed and underdeveloped areas, and they occur where there is a predominance of dark exterior building materials and a lack of vegetation. In dense cities with high temperatures in comparison to surrounding countryside (Figure 3.1), the heat island effect can make city centers warmer, more uncomfortable and occasionally more life threatening (FEMA, 2007). High temperatures increase the use of air conditioners and lead to more energy use. The heat island reduction brings a credit point in LEED rating system and helps to reduce impacts in microclimates, human health and wildlife environment.

Figure 3.1: Urban heat island.



Source: http://heatisland.lbl.gov/ [Accessed 16 November 2014]

In the context of LEED, solar reflectance index (SRI) is the correct measure that accounts for a surface's solar reflectance and emittance. The calculation procedure for SRI is described in ASTM E 1980, *Standard Practice for Calculating Solar Reflectance Index of Horizontal and Low-Slope Opaque Surfaces*. Materials with low solar reflectance such as dark materials absorb heat from the sun as materials with higher solar reflectance such as light-colored materials reflect heat from the sun and do not warm the surrounding air. A minimum of 75 percent of the roofing space must have a SRI equal to or greater than the values shown in the Table 3.4. Roofing materials with a lower SRI value than those listed in the table may be used if the weighted rooftop SRI average meets the following criteria: (*Area Roof Meeting Min. SRI / Total Roof Area x SRI of Installed Roof / Required SRI ≥ 75%).*

Table 3.4: Roof types and SRI

ROOF TYPE	SLOPE	SRI (min.)
Low-sloped roof	≤ 2,12	78
Steep-sloped roof	> 2,12	29

Source: Edited by Dila Vural.

Credits may be gained by placing a minimum of 50 percent of parking spaces under cover. Any roof used to shade or cover parking must have an SRI of at least 29 and be a vegetated green roof or be covered by solar panels that produce energy used to offset some non-renewable resource use. Another option is the installation of a vegetated roof that covers at least 50 percent of the roof area. In this way, plants help to keep the air around the building cool by the evaporation of water. Last but not least, credits may be earned by installation of high-albedo and vegetated roof surfaces that, in combination, meet the following criteria: (*Area Roof Meeting Minimum SRI / 0,75 + Area of Vegetated Roof / 0,5 ≥ Total Roof Area).*

Reduction of interior and exterior light pollution also brings a credit point in LEED. The first option to earn this credit is to reduce interior lighting by 50 percent or more between 11 pm to 5 am. The second option is to shield all non-emergency luminaries with controlled device to mitigate light between 11 pm and 5 am. Concurrently, lighting power must not exceed given standards and classify project with appropriate requirements for zone.

3.3.1.2 Location & planning

Sustainable sites concepts aims to choose a smart location with a well-conceived infrastructure. The building earns six credit points, if it is located close to the alternative transportation and public transportation access with the aim to encourage density and diversity. The building must either be located within 800 meters walking distance of existing or planned commuter rail, light rail or subway station, or be located within 400 meters walking distance of one or more stops for two or more public, campus or private bus lines. Design of bicycle storage and changing rooms bring a credit point and minimizing parking capacity brings two more credit points. These credit categories encourage people to ride bicycles and minimize car use in order to reduce negative environmental impacts of cars and the exhaust gases. Additionally, LEED gives three credit points for the encouragement of the use of low-emitting and fuel-efficient vehicles.

Within the scope of development density and community connectivity, five points are earnable. The construction should be built on previously developed land, either on an existing neighborhood with density of 60,000 square feet per acre or within half a mile (800 meters) of residential zone or neighborhood with average density of ten units per acre and ten basic services. There must be pedestrian access between the building and services. This credit category aims to protect natural areas and create accessibility.

Within the scope of LEED rating system, a brownfield is defined as an abandoned or underused industrial or commercial facility in which redevelopment is allowable. The brownfields in inner cities often result from industries that move to suburban or rural sites, where land and taxes are less expensive. The redevelopment of brownfield provides benefits such as the creation of new jobs, the utilization of existing infrastructure as the removal of contaminants on the site that reduce the negative impacts to human health and the environment and earn a credit point to the project.

Table 3.5: Sustainable sites concepts credit analysis

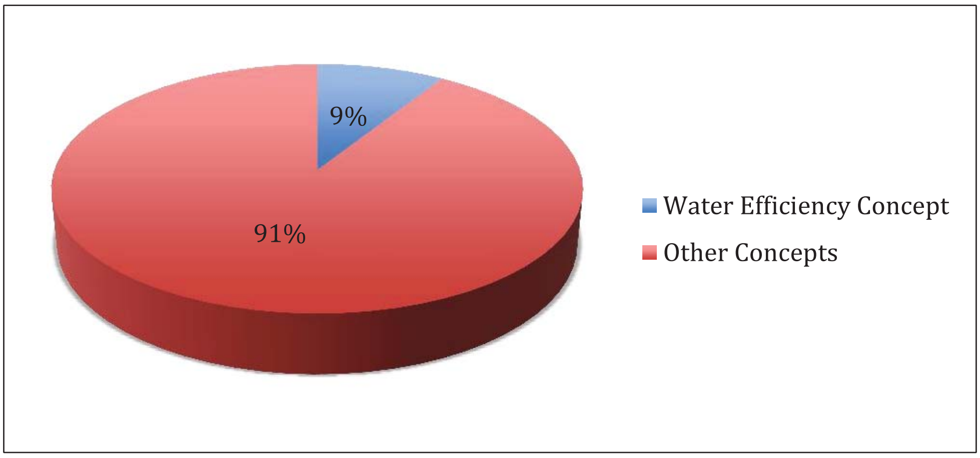
CREDIT	TITLE	POINTS
Prerequisite	Construction Activity Pollution Prevention	Required
Credit 1	Site Selection	1
Credit 2	Development Density & Community Connectivity	5
Credit 3	Brownfield Redevelopment	1
Credit 4.1	Alternative Transportation: Public Transportation Access	6
Credit 4.2	Alternative Transportation: Bicycle Storage & Changing Rooms	1
Credit 4.3	Alternative Transportation: Low-Emitting & Fuel-Efficient Vehicles	3
Credit 4.4	Alternative Transportation: Parking Capacity	2
Credit 5.1	Site Development: Protect or Restore Habitat	1
Credit 5.2	Site Development: Maximize Open Space	1
Credit 6.1	Stormwater Design: Quantity Control	1
Credit 6.2	Stormwater Design: Quality Control	1
Credit 7.1	Heat Island Effect: Non Roof	1
Credit 7.2	Heat Island Effect: Roof	1
Credit 8	Light Pollution Reduction	1
Possible Total Points		**26**

Source: Edited by Dila Vural.

3.3.2 Water Efficiency Concepts

A key element for the sustainability and the green building assessment system is the water efficiency. Water is an infinite renewable resource dissimilar to oil or coal. However, the rapid population growth particularly in developing countries caused reduction of available water supply per person. Moreover, the unsustainable water uses such as mismanagement, overuse and waste of water in urban, industrial and agricultural areas increased water demand (Postel, 1993). As a result, water is gradually becoming more important than it was in the past. Consequently, higher productivity and efficiency of the water used in the building sector is necessary. With tools and new technologies for conserving, recycling and reusing of water, it is possible to save water and increase the efficiency of water use. As all the other green building assessment systems, LEED-NC includes water efficiency credits. This section consists of a prerequisite, three parts and ten possible points. The water concept includes reduction in losses, reduction in overall water use, re-use and conservation measures.

Table 3.6: Percentage distribution of water efficiency credit category



Source: Edited by Dila Vural.

Water efficiency concepts consist of indoor, outdoors and process water with the aim to reduce potable water demand, increase water use efficiency and reduce environmental impact. The credit categories are water efficient landscaping, innovative wastewater technologies and water use reduction (Table 3.7).

Table 3.7: Water efficiency concepts credit analysis

CREDIT	TITLE	POINTS
Prerequisite	Water Use Reduction	Required
Credit 1	Water Efficient Landscaping	2-4
Credit 2	Innovative Wastewater Technologies	2
Credit 3	Water Use Reduction	2-4
Possible Total Points		**10**

Source: Edited by Dila Vural.

The single prerequisite requires 20 percent less water use than water-use baseline calculated for building (not including irrigation). The baseline usage is based on the requirements of the US Energy Policy Act of 1992 and subsequent rulings by the Department of Energy, the requirements of the US Energy Policy Act of 2005 and the fixture performance standards in the 2006 editions of the Uniform Plumbing Code or International Plumbing Code as to fixture performance (Table 3.8). The percentage of water use reduction assesses the earned credit point (Table 3.9).

Table 3.8: Water use baseline

COMMERCIAL FIXTURES OF WATER USE	CURRENT BASELINE (IMPERIAL UNITS)
Toilets	1,6 gallons per flush
Urinals	1,0 gallons per minute
Lavatory Faucets	2,2 gallons per minute

Source: Edited by Dila Vural.

Table 3.9: Percentage of water use reduction

PERCENTAGE OF WATER USE REDUCTION	POINTS
30%	2
35%	3
40%	4

Source: Edited by Dila Vural.

To earn two to four points within the credit category of water efficient landscaping, the first option is to reduce potable water consumption by 50 percent or more. The second option is to meet the preceding one, and either use exclusively captured rainwater, recycled wastewater, recycled grey water or municipally supplied non-potable irrigation water or use no permanent irrigation system.

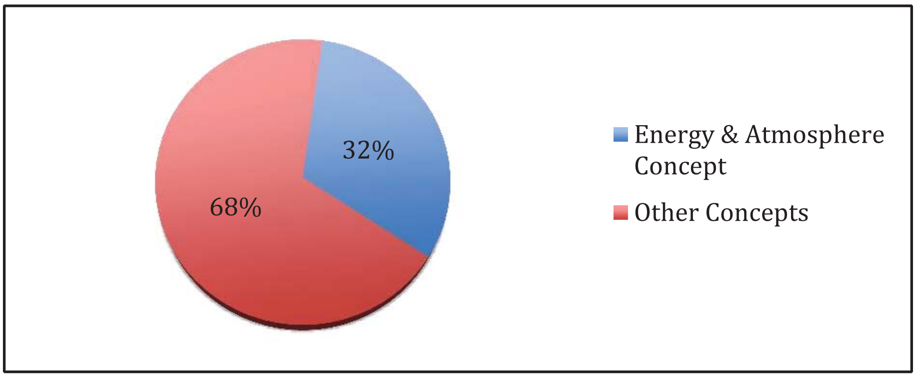
The intent of the credit category of innovative wastewater technologies is to reduce the amount of potable water used for flush fixtures and to minimize the amount of wastewater conveyed to the municipal system. The first option to earn credits is to reduce the quantity of potable water used for water closet and urinals by 50 percent. This may be achieved by using water-conserving fixtures or non-potable water such as recycled grey water or captured rainwater or a combined system. The second option is to treat 50 percent of wastewater onsite to tertiary standards and infiltrate.

3.3.3 Energy & Atmosphere Concepts

The building and the energy sectors are the integral part of sustainability. Recently, improving a building's energy performance by evaluating the building's energy consumption and simulating multifold optimization scenarios is an inevitable step of design phase. In order to improve a building's energy efficiency in regard to heating and cooling, simple measures such as installing storm windows, using double-glazed windows and adding insulation materials to existing frame construction buildings are relatively inexpensive and proven alternatives. Insulation materials vary from mineral, fibrous to cellulose-derived materials. Besides, on account of the fact that a building's heating ventilation and air conditioning (HVAC) system uses large amounts of energy, properly designed and installed HVAC systems can minimize the amount of energy used for heating and cooling.

Within the LEED rating system, 35 total points are possible to earn due to the credit category of energy and atmosphere concepts. This category deals with reducing energy demand and environmental impact for instance by limiting use of refrigerants, as with energy supply by purchasing off-site renewable energy and using incident energy. Moreover, recognizing energy baselines (ASHRAE 90.1-2007) and identifying opportunities for efficiency helps to increase energy performance. In order to get points from six major topics, three prerequisites are to be fulfilled. These consist of fundamental commissioning of building energy systems, minimum energy performance and fundamental refrigerant management.

Table 3.10: Percentage distribution of energy and atmosphere credit category



Source: Edited by Dila Vural.

Systems to be commissioned are HVAC and controls, interior and exterior lighting, domestic hot water, renewable energy systems. In addition to the requirements of the first prerequisite, two points may be earned by implementing commissioning process activities. LEED commissioning authority must be experienced, independent of design team, report findings directly to owner and be owner, employee or consultant. In order to get credit points from enhanced commissioning category, the authority may not be employee of design or construction team as not be contracted through construction team. The second prerequisite requires whole building simulation and an energy saving by minimum five percent in existing buildings. The values must comply with ASHRAE Advanced Energy Design Guide.

Table 3.11: Energy and atmosphere concepts credit analysis

CREDIT	TITLE	POINTS
Prerequisite	Fundamental Commissioning of Building Energy Systems	Required
Prerequisite	Minimum Energy Performance	Required
Prerequisite	Fundamental Refrigerant Management	Required
Credit 1	Optimize Energy Performance	1-19
Credit 2	On-site Renewable Energy	1-7
Credit 3	Enhanced Commissioning	2
Credit 4	Enhanced Refrigerant Management	2
Credit 5	Measurement & Verification	3
Credit 6	Green Power	2
Possible Total Points		**35**

Source: Edited by Dila Vural.

To earn up to 19 points, 8-44 percent improvement must be achieved with the help of whole building simulation (Table 3.12). Only one credit can be earned by meeting ASHRAE Advanced Energy Design Guides. Implementing measurement and verification plan provides three points and installing on-site renewable energy systems one to seven points (Table 3.13). Eligible Renewable Energy Systems include solar thermal, photovoltaic, wind and biomass power. Contracting with local utility for green power and using minimum 35 percent of renewable energy can provide two credit points.

Table 3.12: Optimize energy performance credit analysis according to ASHRAE 90.1-2007

RATE OF OPTIMIZED ENERGY IN EXISTING BUILDINGS	POINTS
8%	1
10%	2
12%	3
14%	4
16%	5
18%	6
20%	7
22%	8
24%	9
26%	10
28%	11
30%	12
32%	13
34%	14
36%	15
38%	16
40%	17
42%	18
44%	19

Source: Edited by Dila Vural.

Table 3.13: Rate of renewable energy credit analysis

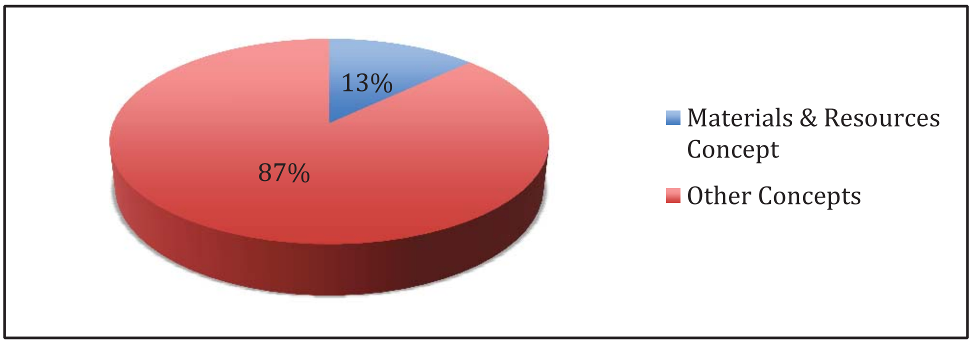
RATE OF RENEWABLE ENERGY	POINTS
1%	1
3%	2
5%	3
7%	4
9%	5
11%	6
13%	7

Source: Edited by Dila Vural.

3.3.4 Materials & Resources Concepts

Within the scope of materials and resources concepts, the project can gain 14 credit points under the condition that the prerequisite of storage and collection of recyclables is fulfilled. The first step is to provide easily accessible, dedicated area for collection and storage of recycled materials for the entire building. This must include paper, cardboard, glass, plastics and metals. Assessment of the project under eight credit categories aims to increase the amount of recyclable building materials, examine re-use of waste and support use of regional materials (Figure 3.15).

Table 3.14: Percentage distribution of materials & resources credit category



Source: Edited by Dila Vural.

Table 3.15: Materials and resources concepts credit analysis

CREDIT	TITLE	POINTS
Prerequisite	Storage & Collection of Recyclables	Required
Credit 1	Building Reuse: Maintain Existing Walls, Floors, Roof	1-3
Credit 1.1	Building Reuse: Maintain Interior Nonstructural Elements	1
Credit 2	Construction Waste Management	1-2
Credit 3	Materials Reuse	1-2
Credit 4	Recycled Content	1-2
Credit 5	Regional Materials	1-2
Credit 6	Rapidly Renewable Materials	1
Credit 7	Certified Wood	1
Possible Total Points		**14**

Source: Edited by Dila Vural.

3.3.4.1 Waste reduction

The aim of this credit category is to divert and re-use waste as to reduce waste generation. Construction waste management includes two credit points for the project (Table 3.16). The Ministry of Environment and Forestry carries out the implementation of legal arrangements in Turkey, and municipalities and public institutions are also involved. The waste management system is not a priority policy area and does not have an established institutional infrastructure authorized at both national and local levels (Köse, Ayaz and Köroğlu, p.11). In renovation projects, structural and interior nonstructural elements may be reused in order to prevent waste. Using existing interior non-structural elements in at least 50 percent of the completed building brings a credit point. To earn up to three credit points, existing structure and envelope including walls, floors and roof can be maintained and reused (Table 3.17).

Table 3.16: Rate of construction waste reuse credit analysis

RATE OF CONSTRUCTION WASTE REUSE	POINTS
50%	1
75%	2

Source: Edited by Dila Vural.

Table 3.17: Rate of building materials reuse credit analysis

RATE OF BUILDING MATERIALS REUSE	POINTS
55%	1
75%	2
95%	3

Source: Edited by Dila Vural.

3.3.4.2 Materials impact

To minimize materials impact, materials with less lifecycle can be selected; salvaged, refurbished or reused materials can be used (Table 3.18). To earn two credit points, regional materials or products extracted, harvested, improved or manufactured within 800 km of project site can be used (Table 3.19). Rapidly renewable materials and products must have a planting to harvest cycle of 10 years or less. These are natural; non-petroleum based building materials including bamboo, agrifibers cork, corn, cotton, linoleum and wool. One point can be earned for two and a half percent rapidly renewable material by cost. Two points can be earned according to the rate of recycled content use in the building (Table 3.20). Wood is among the most sustainable building materials. The certified wood credit is the most important driver of forest conservation and management in history. The requirements for the credit is to use a minimum of 50 percent (based on cost) of wood based materials and products that are certified by Forest Stewardship Council (FSC).

Table 3.18: Rate of materials reuse credit analysis

RATE OF MATERIALS REUSE	POINTS
5%	1
10%	2

Source: Edited by Dila Vural.

Table 3.19: Rate of regional materials use credit analysis

RATE OF REGIONAL MATERIALS USE	POINTS
10%	1
20%	2

Source: Edited by Dila Vural.

Table 3.20: Rate of recycled content use credit analysis

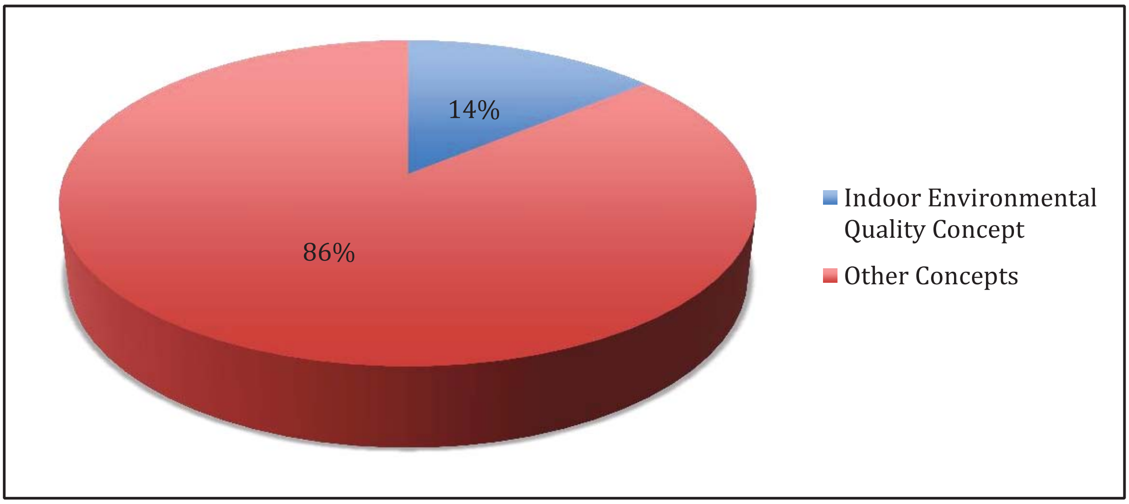
RATE OF RECYCLED CONTENT USE	POINTS
10%	1
20%	2

Source: Edited by Dila Vural.

3.3.5 Indoor Environmental Quality Concepts

The indoor environmental quality category rewards decisions made about indoor air quality, thermal and visual comfort and occupants' fulfillment with two prerequisites and 15 key considerations each with one credit points. Minimum indoor air quality performance and Environmental Tobacco Smoke (ETS) Control are required for the assessment. Smoking is not allowed in the building and within eight meters of entries as designated smoking rooms that contains, captures and removes ETS are to be provided. High-quality indoor environments increase productivity. To achieve this, the project team must control thermal comfort, consider acoustics, ensure lighting satisfaction, and provide daylight and views. High indoor thermal comfort can be achieved with monitoring and controlling of the relevant system.

Table 3.21: Percentage distribution of indoor environmental quality credit category



Source: Edited by Dila Vural.

Outdoor air delivery monitoring is one of the credit categories with one point that request, in case of mechanical ventilation, monitoring of CO_2 concentrations within all densely occupied spaces and measuring of the direct outdoor airflow. In case of natural ventilation, monitoring CO_2 concentrations within each space is required.

Table 3.22: Indoor environmental quality concepts credit analysis

CREDIT	TITLE	POINTS
Prerequisite	Minimum Indoor Air Quality Performance	Required
Prerequisite	Environmental Tobacco Smoke (ETS) Control	Required
Credit 1	Outdoor Air Delivery Monitoring	1
Credit 2	Increased Ventilation	1
Credit 3.1	Construction Indoor Air Quality Management Plan During Construction	1
Credit 3.2	Construction Indoor Air Quality Management Plan Before Occupancy	1
Credit 4.1	Low-Emitting Materials: Adhesives & Sealants	1
Credit 4.2	Low-Emitting Materials: Paints & Coatings	1
Credit 4.3	Low-Emitting Materials: Flooring Systems	1
Credit 4.4	Low-Emitting Materials: Composite Wood & Agrifiber Products	1
Credit 5	Indoor Chemical & Pollutant Source Control	1
Credit 6.1	Controllability of Systems: Lighting	1
Credit 6.2	Controllability of Systems: Thermal Comfort	1
Credit 7.1	Thermal Comfort: Design	1
Credit 7.2	Thermal Comfort: Verification	1
Credit 8.1	Daylight & Views: Daylight	1
Credit 8.2	Daylight & Views: Views	1
Possible Total Points		**15**

Source: Edited by Dila Vural.

3.3.5.1 Indoor air quality

According to EPA, Americans spend about 90 percent or more of their time inside the house. Indoor levels of pollutants may be two to five times higher, and even sometimes more than 100 times higher, than outdoor levels. This situation affects the health and well being of the occupants negatively. Because of this reason, indoor air quality is a primary consideration of green building rating systems. In order to reduce the presence of harmful air inside, indoor air should be frequently replaced by filtered outdoor air. The so-called ventilation can be done by natural or mechanical practices. In order to earn credits, project team must design appropriately ventilated building, promote green construction practices, control moisture, select low-emitting materials and reduce or eliminate contaminants.

In case of mechanical ventilation, each outside air intake must be modified; ventilation distribution system or air fan must be supplied. In case of natural ventilation, the requirements for location and size of ventilation openings must be provided according to ASHRAE 62.1-2007 standards.

The “sick building syndrome” is a common problem that many older buildings suffer. This situation caused by inadequate ventilation, chemical substances from indoor and outdoor sources or biological substances such as mold is regarded as the experience of acute health and comfort problems that appear in building’s occupants. In order to prevent the sick building syndrome, the choice of materials used in the building (adhesives and sealants, paints and coats, flooring systems, composite wood and agrifiber products, furniture and furnishings, ceilings and wall systems) is crucial. The chosen materials should emit zero or low levels of volatile organic compounds (VOCs) in order to prevent the vaporization of harmful compounds at room temperature, which is called the off-gassing process. Paints and coatings used on interior of building must comply with VOC content limit requirements of reference standards based on project scope.

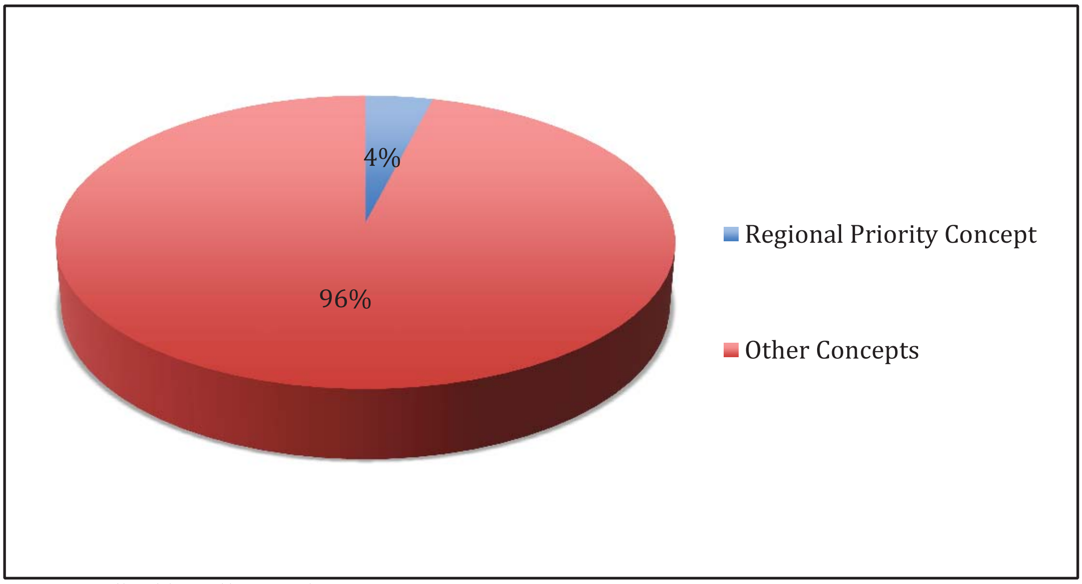
3.3.5.2 Occupant comfort & productivity

The intent of daylight and views category is to connect building occupants with the outdoors, highlight circadian rhythms and decrease the use of electrical lighting. The controllability of lighting category requires providing individual lighting controls for 90 percent of occupants; provide lighting system controllability for all shared multi-occupant spaces. Controllability of thermal comfort requires providing individual comfort controls for 50 percent of building occupants and for all shared multi-occupant spaces. Daylight with a minimum of 100 lux in 75 percent of occupied spaces is rewarded with one point. In order to earn one more point, direct line of sight to outdoor environment via vision glazing between 76 cm and 230 cm above finish floor for building occupants in 90 percent of all regularly occupied areas must be achieved.

3.3.6 Regional Priority

The concept of regional priority credits aims to incentivize the achievement of credits that address geographically specific environmental priorities and four points can be earned, but international projects cannot earn any credit points.

Table 3.23: Percentage distribution of regional priority credit category



Source: Edited by Dila Vural.

Table 3.24: Regional priority concepts credit analysis

CREDIT	TITLE	POINTS
Credit 1	Regional Priority	1-4
Possible Total Points		**4**

Source: Edited by Dila Vural.

3.3.7 Innovation In Design

Innovation in design provides six points under the assessment of two major headings, innovation in design and a LEED accredited professional (Table 3.25).

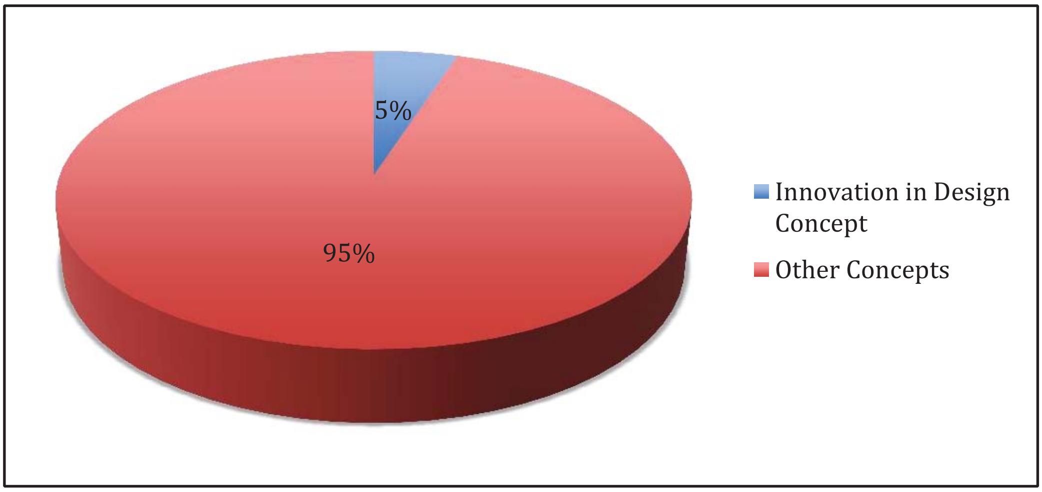
Table 3.25: Innovation in design concepts credit analysis

CREDIT	TITLE	POINTS
Credit 1	Innovation in Design	1-5
Credit 2	LEED Accredited Professional	1
Possible Total Points		**6**

Source: Edited by Dila Vural.

Achieving exemplary performance provides three points and innovative measure provides two points. In order to get the points, the intent of proposed credit, requirements and strategies as submittals to demonstrate compliance must be identified and available pilot credits must be attempted.

Table 3.26: Percentage distribution of innovation in design credit category



Source: Edited by Dila Vural.

3.4 SYNERGIES BETWEEN LEED CREDITS

Synergies in LEED are essential to design successful green buildings. Understanding the interconnection between LEED credits may contribute to more than one LEED credit. For instance, as listed in Green Exam Academy[2], rainwater collection reduces quantity of stormwater to be managed, is resource for landscape irrigation as well as source of non-potable water for flushing toilets or urinals, and provides opportunity to displace potable water use for HVAC. Similarly, daylighting can reduce need for electrical lighting, secure savings in electricity, provide passive solar heating and authorize elimination of perimeter heating. Nevertheless, daylighting in cold-climate can mean poor insulation and could raise overall heating loads and as inappropriate fenestration, can lead to overheating of occupants near windows and result with higher loads at summertime.

Last but not least, a vegetated roof simultaneously helps reduction of roof rainwater runoff as well as reduction of heat island effects, and provides an added layer of insulation to prevent escape of winter heating energy from the building. This also diminishes cooling loads by buffering roof membrane from sun exposure and through evapo-transpiration. In conclusion, a vegetated roof helps to save costs by allowing downsizing of cooling equipment and decreasing electric power demand.

[2] Green Exam Academy, 2008. Free Online LEED AP Exam Study Guide, http://www.greenexamacademy.com/leed-synergies/, [Accessed 19 November 2014]

3.5 CERTIFICATION PROCESS

The LEED-NC certifications are available, only if the construction is finished and they are awarded according to the following scale:

40-49 points: Certified
50-59 points: Silver
60-79 points: Gold
80 + points: Platinum

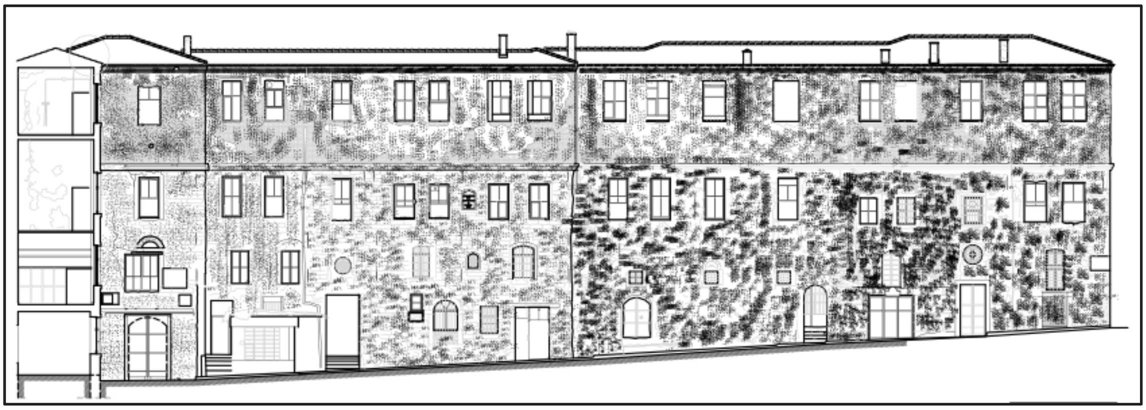
LEED-NC consists of eight prerequisites, 49 credit categories and possible 110 points. The performance standards may be used throughout the design and construction phase of the project and suggestions may be given to the project team in order to gain more credits for the building.

4. A CASE STUDY: ST. PIERRE HAN

One of the most important historic building in Istanbul, St. Pierre Han, which served as a trade center for Genoese, later as a cultural and financial center for Ottoman, will be restored and adaptively re-used by Bahçeşehir University in order to serve for educational facilities. By preserving the historic building and adding a new function as a cultural and educational arts center, the new generation will be able to study within the city context.

This thesis aims to analyze the *han* building within the context of green preservation for historic buildings in the scope of LEED certification system and give advices to the project team for a green retrofitting. St. Pierre Han in Galata will be evaluated in the scope of LEED-NC rating and certification system. First of all, a historic background study of the case study building is necessary. The analysis of the case-study building is placed with regard to the criteria set forth by LEED rating and certification system.

Figure 4.1: Front façade of St. Pierre Han



Source: Halil Onur - Ali Çiçek Mimarlık, 2012.

4.1 HISTORICAL DEVELOPMENT OF ST. PIERRE HAN

The case study building selected for the study is the 400-year-old St. Pierre Han, located in the Galata district of Istanbul. It is a representative building and considered to be typical as well as an important magnitude of the area in this region. Istanbul's Galata district has always been important all through its historic development. Since 14th century, St. Pierre Church and the St. Pierre building complex served as a Latin Catholic Church to Dominican sect. Numerous additions have been made to the buildings complex through its history. It consists of the old and new convents, a school, an apartment building, the church and a *han* building.

St. Pierre Han is the main study object of this thesis. Dating back to 18th century, this *han* building is an important constituent of this region. Through its historical development, the *han* building was used for different functions. The present building, which served as a trade center, was built by the Genoese Community in 1772. It was designed and built for the French Kingdom and lodging facilities. Later, the building was the first home of the Ottoman Central Bank, which was established in 1863. After the move of the Ottoman Central Bank, the *han* building housed the Constantinople Law Society and the Italian Chamber of Commerce. Later on it is used as an office building for merchants, architects and lawyers. The present function of St. Pierre Han is small industry. A plaque of St. Priest and the royal arms of the Kingdom of France are to be found on the façade of the building. The Levantine architect Alexander Vallaury also attached a plaque to the building in the 20th century in commemoration of the French poet André Cheniér (Figure 4.3). According to some references, the famous French poet was born in former *han* building. Currently, Bahçeşehir University (BAU) chartered this old and derelict (vacant) historic building with the purpose to restore and re-use it as a cultural arts center. The 3.000-square-meter building is built of load-bearing, faced stone masonry. It is an inspiring building to re-create culture and therefore it serves as the office of the Institute of Creative Minds (ICM).

These items were the reason for the building to be chosen for to study and later they played an important role in determining the new function of the *han* building.

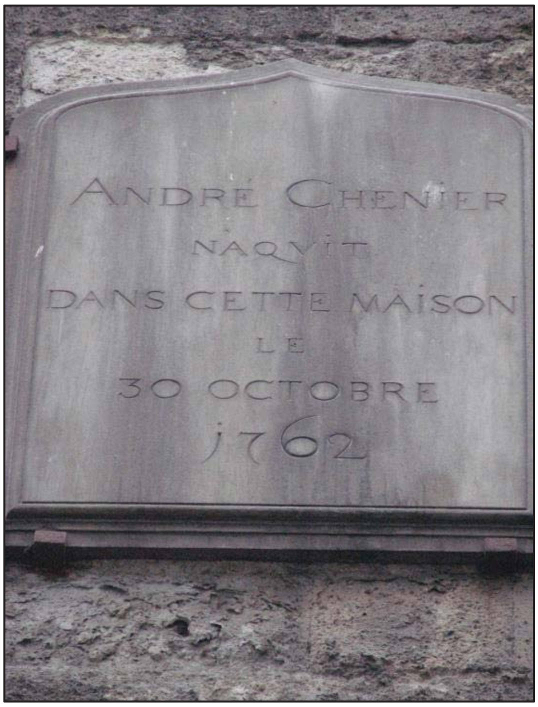
4.2 EVALUATION OF ST. PIERRE HAN IN THE SCOPE OF LEED-NC

St. Pierre Han is evaluated with regard to the criteria set forth by LEED certification system, the energy simulation of the building is studied and advices are given to the project team in order to earn more credits for the building towards credit categories of LEED-NC. The credit earnings through the current state of the building and the situation in which the given advices are applied are analyzed. Within the context of this thesis, the credits earned through the current state of the *han* building are evaluated under the name of "earned credit"; the credits which can be earned in accordance with the building renovation advices to the project team are named "potential credit". The building is analyzed within six credit categories, which consist of sustainable sites, water efficiency, energy and atmosphere, materials and resources, indoor environmental quality, and innovation in design. International projects cannot be evaluated in the scope of the seventh category, which is the regional priority.

Figure 4.2: St. Pierre Han

Source: http://www.envanter.gov.tr/anit [Accessed 23 December 2014]

Figure 4.3: St. Pierre Han



Source: http://www.envanter.gov.tr

4.2.1 Sustainable Sites Concepts

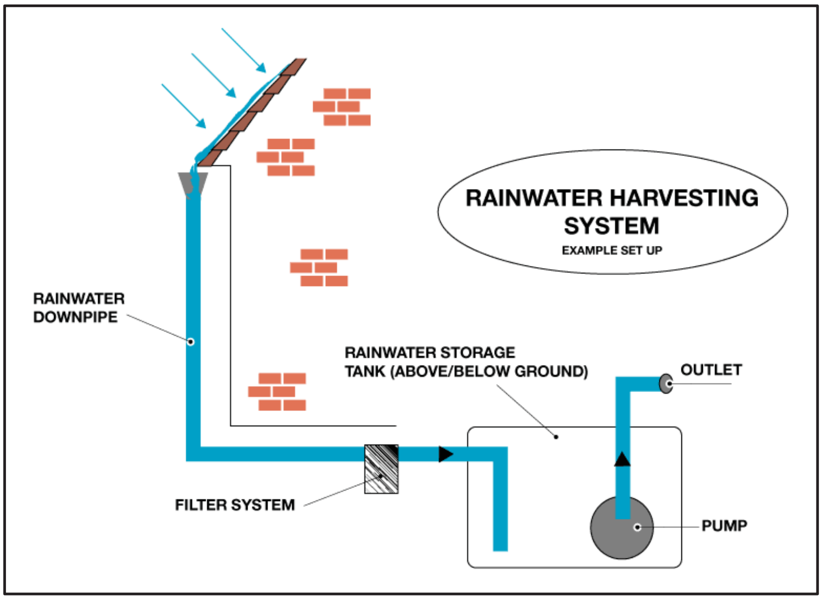
St. Pierre Han can have several achievements in the sustainable sites credit category. First, the prerequisite, to prevent construction activity pollution in order to prevent polluting air with dust and particulate matter, is to be fulfilled. Site design and management is the first step to get points from this credit category. Location and planning is the second important sub-heading in this concept in order to earn more credit points.

As the building was initially used to house small industry and currently it is a vacant building, the site may be qualified as a brownfields redevelopment. However, the site is not documented as contaminated by means of an ASTM E1903-97 Phase II Environmental Site Assessment or a local voluntary cleanup program. The project cannot earn any points under this LEED title. The site stormwater management system can collect and filter rainwater from the roof for toilet flushing. A cistern in the basement floor can hold water collected from the roof and re-circulate it for plumbing.

4.2.1.1 Site design & management

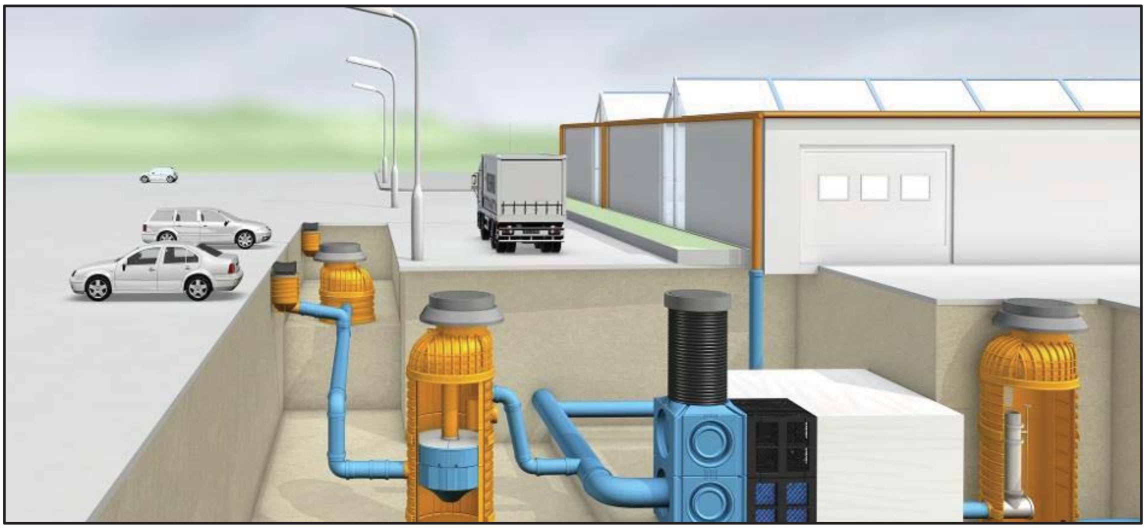
Quantity and quality controls each with one credit point within the stormwater design help rainwater management and collect water from building and store it for reuse in order to prevent increased stormwater runoff due to impervious surfaces like roofs. To earn this credit, in case of existing imperviousness of 50 percent or less, post-development must discharge less than pre-development or receiving stream channels must be protected from excess erosion. Green roofs are favorable in these cases, but the most advantageous option is to encourage natural infiltration of stormwater into the ground. Installed pervious pavers, loose gravel as wood deck or steps filled with gravel in the courtyard and sidewalk can allow rainwater to infiltrate into the ground and return to nature instead of running into the central sewer system. The outdoor wood can be certified by FSC. Within the quality control of stormwater, the aim is to capture and treat 90 percent of average annual stormwater runoff and remove 80 percent of total suspended solids. Integrated rainwater harvesting system can save up to 50 percent of water consumption. As an instance, innovative, modular and flexible rainwater management solution, the Raustorm Box by Rehau, is a tank system that stores or recharges ground water using the rainwater on site and is applicable for the project.

Figure 4.4: Rainwater harvesting system



Source: http://www.rainwindsun.com [Accessed 16 December 2014]

Figure 4.5: Raustorm Box for rainwater management by Rehau



Source: http://www.rehau.com [Accessed 21 December 2014]

The heat island reduction brings a credit point in LEED rating system. Light colored paving and a high-emissivity roof help reduce urban heat island effect. In the context of LEED, SRI is the correct measure that accounts for a surface's solar reflectance and emittance. Materials with a minimum of 78 SRI need to be used in the pavement for potential credit. The roof can be covered by solar panels that produce energy used to compensate some non-renewable resource use.

Reduction of interior and exterior light pollution also brings a credit point in LEED. Accordingly, light pollution caused by light trespass toward sky or outside causes glare, reduces sky view and damages ecosystem. The first option to earn this credit is to reduce interior lighting by 50 percent or more between 11 pm to 5 am. Exterior lighting needs to be disabled after 11 pm. The second option is to shield all non-emergency luminaries with controlled device to mitigate light between 11 pm and 5 am. Concurrently, lighting power must not exceed given standards and classify project with appropriate requirements for zone. LED light sources, control with automation, dim availability and limited landscape lighting help to minimize light trespass as light pollution and also save energy.

Figure 4.6: Site map of St. Pierre Han.

Source: Google Earth [Accessed 6 December 2014]

4.2.1.2 Location & planning

St. Pierre Han is located in a previously developed site, which earns the project a credit. Within the scope of development density and community connectivity, five credit points are earnable. The *han* building is located on previously developed land, and within 800 meters of residential zone as at least ten basic services. These consist of library, banks, school, sports center, health center, beauty center, park, museum, pharmacy, dry cleaning, post office, and restaurant. Galata district of Istanbul is one of the oldest and historical centers of the city. A pedestrian access between the building and services are available. The building is within 800 meters of Istanbul's prominent pedestrian street, Istiklal Street, and the adjoining Taksim Square. So, St. Pierre Han is within walking distance to city center, Pera Museum, Istanbul Modern, St. George Hospital, St. George's Austrian High School, Beyoğlu's post office, Taksim Gezi Park and the library of SALT Galata.

Figure 4.7: Site map of St. Pierre Han.

Source: Google Earth [Accessed 6 December 2014]

There is also access to the free public transportation in Istanbul. In addition to these transportation options, the Karaköy district has a trolley line that connects it to other locations in Istanbul and to the marine transportation. So, the *han* building is located on the streetcar line and is close to several bus routes and underground stations. The project can earn a potential credit by providing bicycle parking spaces, lockers and sufficient showers on site to persuade further modes of transportation such as biking. Bicycle parking spots and shower facilities make bike commuting easier for employees, students and other visitors. Car parking is limited due to the narrow streets and the location of the building. In case there are workers or students who cannot reach the building by using one of these modes of transportation, a low-emitting, fuel-efficient service trolley can be brought into use. A parking area can be provided for at least three service trolleys and for public transport vehicles. Three potential credit points are available under the category of alternative transportation by low-emitting, fuel-efficient vehicles. Additionally, two potential credit points are available in the category of parking capacity, if the advices given are applied to the project.

4.2.1.3 Evaluation result of St. Pierre Han in the scope of sustainable sites concepts

In sustainable sites concept, 26 possible points can be earned, but the building can only earn 12 points with its current situation and potential 11 points if the advices given are implemented to the project. The categories of brownfield redevelopment, site development by protecting and restoring habitat and maximizing open space cannot be achieved in this project because more than half of the site is covered with the existing historic building. The green area to be planned is limited on the site due to the historical structure of the case building.

Table 4.1: Sustainable sites concepts evaluation result

CREDIT CATEGORY	CREDIT	EARNED CREDIT	POTENTIAL CREDIT
Site Selection	1	1	-
Development Density & Community	5	5	-
Brownfield Redevelopment	1	-	-
Alternative Transportation: Public Transportation Access	6	6	-
Alternative Transportation: Bicycle Storage & Changing Rooms	1	-	1
Alternative Transportation: Low-Emitting & Fuel-Efficient Vehicles	3	-	3
Alternative Transportation: Parking Capacity	2	-	2
Site Development: Protect or Restore Habitat	1	-	-
Site Development: Maximize Open Space	1	-	-
Stormwater Design: Quantity Control	1	-	1
Stormwater Design: Quality Control	1	-	1
Heat Island Effect: Non Roof	1	-	1
Heat Island Effect: Roof	1	-	1
Light Pollution Reduction	1	-	1
Overall Evaluation	**26**	**12**	**11**

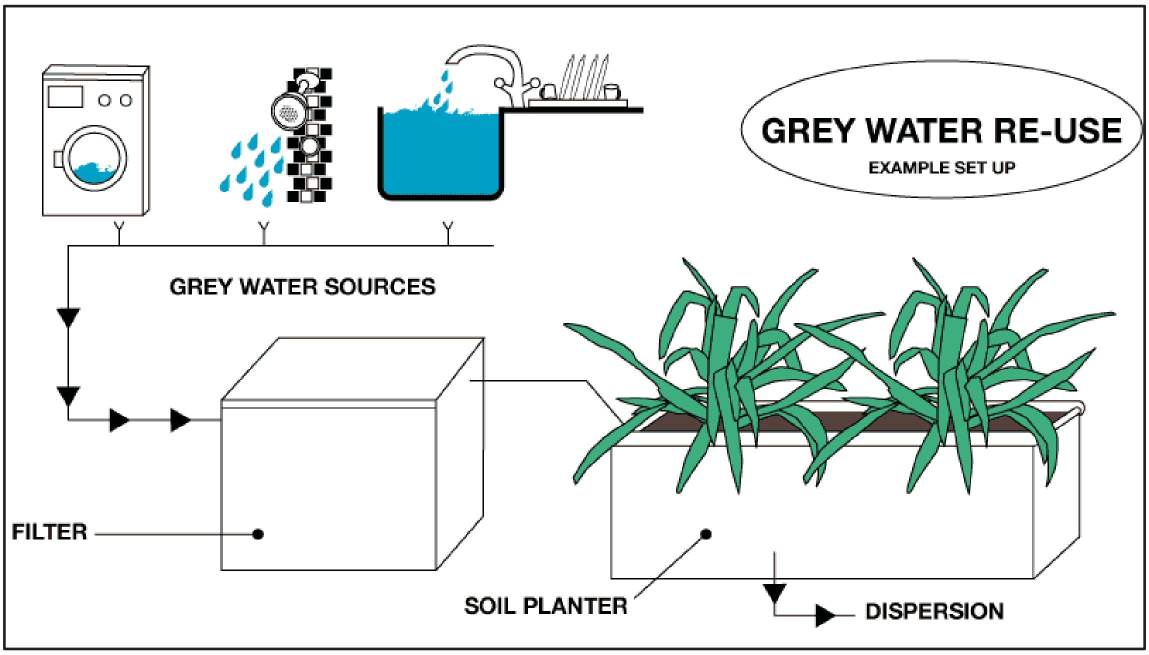
Source: Edited by Dila Vural.

4.2.2 Water Efficiency Concepts

Considering water efficiency concepts, ten credit points are earnable under three credit categories with the help of landscape architects and mechanical engineers. As water is an increasingly valuable resource, new strategies and systems are developing all over the world in order to reduce water usage. The *han* building can achieve at least 30 percent water savings which earn the project minimum two posible points. The project team can achieve up to 50 percent water saving by using water-efficient flow fixtures, dual flush water closet reservoirs, waterless urinal and recycling rainwater from the roof into the cistern in the basement floor for use in toilet flushing. As an instance, innovative EcoJoy products such as basin faucets and fittings by Grohe can help clients to navigate the green building rating systems. They feature a restricted flow of not more than 5,8 l/min. In addition, VitrA/Artema products help to achieve green solutions for projects with the concern to minimize their ecological footprint. For example, a dual flush water closet reservoir features a restricted flow of 2,5-4 liter per cycle and saves water for 51 percent. These green products not only help to reduce water use, but also help to earn credits in categories of innovative wastewater technologies, regional materials, low-emitting materials and innovation in design. As a result of these, reduction of stormwater runoff and potable water use may be possible.

A grey water system (Figure 4.6) is also a green strategy for sustainable buildings. Collected water from washbasins, showers, baths and sinks can be delivered to grey water line and be recycled on-site in order to be used as WC-flushing, landscape irrigation, laundry, general cleaning, fire extinguishing and vehicle washing after biological treatment. Besides, water from dish machine, washing machine and kitchen sink is not available as grey water due to high amount of detergent and oil they contain. So, an integrated water management system and water efficient flow fixtures as low-flow faucets and dual-flush toilets can help reduction of potable water demand by minimum 30 percent in this renovation project.

Figure 4.8: Grey water re-use system



Source: http://www.rainwindsun.com [Accessed 20 December 2014]

4.2.2.1 Evaluation result of St. Pierre Han in the scope of water efficiency concepts

In water efficiency concepts, ten possible points can be earned, but the building cannot earn any points by its current situation. Potential six points can be earned if the advices given are implemented to the project. These consist of innovative wastewater technologies that are grey water and rainwater harvesting systems and the reduction of water use. Due to the limitations in green area, landscape irrigation system is not necessary and the project cannot gain points under water efficient landscaping.

Table 4.2: Water efficiency concepts evaluation result

TITLE	CREDIT	EARNED CREDIT	POTENTIAL CREDIT
Water Efficient Landscaping	2-4	-	-
Innovative Wastewater Technologies	2	-	2
Water Use Reduction	2-4	-	4
Overall Evaluation	**10**	**-**	**6**

Source: Edited by Dila Vural.

4.2.3 Energy & Atmosphere Concepts

Within the LEED rating system, energy and atmosphere concepts include the highest credit points with 35 in total. This category deals with reducing energy demand and environmental impact for instance by limiting use of refrigerants, as with energy supply by purchasing off-site renewable energy and using incident energy. Moreover, recognizing energy baselines (ASHRAE 90.1-2007) and identifying opportunities for efficiency helps to increase energy performance. In order to get points from six subheadings, three prerequisites are considered as fulfilled. These consist of fundamental commissioning of building energy systems, minimum energy performance and fundamental refrigerant management.

Systems to be commissioned are HVAC and controls, interior and exterior lighting, domestic hot water, renewable energy systems. In addition to the requirements of the first prerequisite, possible two points may be earned by implementing commissioning process activities. LEED commissioning authority must be experienced, independent of design team, report findings directly to owner and be owner, employee or consultant. In order to get credit points from enhanced commissioning category, the authority may not be employee of design or construction team as not be contracted through construction team. The second prerequisite requires whole building simulation and an energy saving by minimum five percent in existing buildings.

To earn up to 19 points, a minimum of eight percent improvement must be achieved with the help of whole building simulation (Table 4.13 and 4.14). Only one credit can be earned by meeting ASHRAE Advanced Energy Design Guides. Implementing measurement and verification plan provides three points and installing on-site renewable energy systems one to seven points. Eligible renewable energy systems include solar thermal, photovoltaic, wind and biomass power. Contracting with local utility for green power and using minimum 35 percent of renewable energy can provide two credit points.

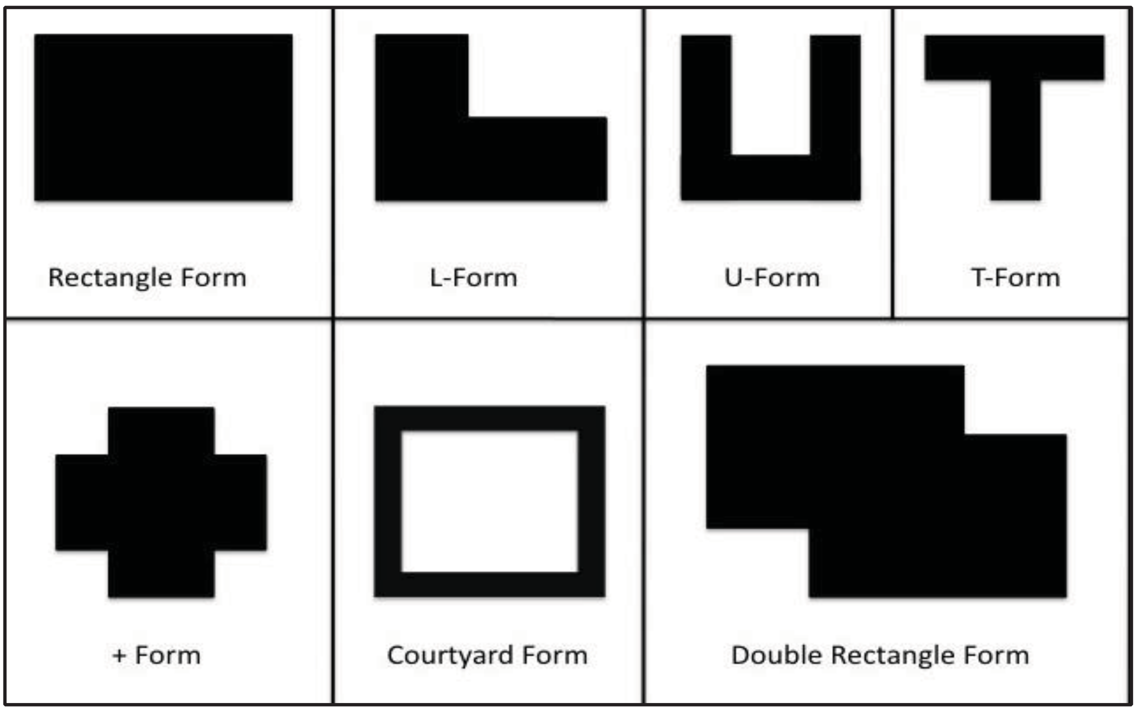
Figure 4.9: Skylights of St. Pierre Han

Source: Halil Onur - Ali Çiçek Mimarlık, 2012.

The skylights on the ceiling provide ample natural light for the rooms and corridors during the day. Glazing systems with a 45 percent visual light transmittance may be used to reduce electric light use, minimize winter heat loss, air infiltration and summertime heat gains. The thermal transmittance of windows is an important issue of sustainable strategies. Heat is lost through the frame, glazing and seals. Triple and double glazed windows are suggested with a U-value of 0,88 watt per meters squared Kelvin. The gap between low-e and Ecotherm glasses is filled with argon gas. Photo-sensors can help to turn down the lights when the sun is bright enough to provide ample lighting. The motion sensors also can help to turn the lights off completely when people are not in the space. Dimming system reduces energy use in rooms and corridors. Using an energy model, BEP-TR, to estimate energy usage and test energy efficiency measures, the retrofitted building is expected to achieve energy savings over the initial one.

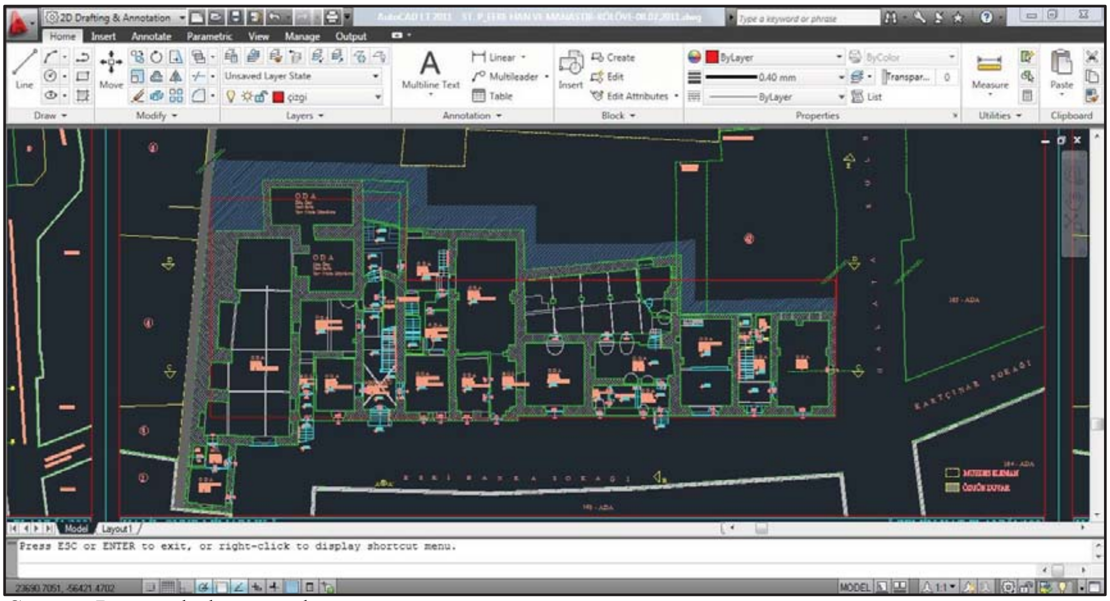
The EU legislated Energy Performance of Buildings Directive (EPBD) 2002/91/EC dictates that each member state should develop a methodology to calculate energy performance of buildings. Following this, Energy Performance of Buildings Directive became effective in Turkey in 2009, and calculation methodologies were developed such as the national calculation methodology, BEP-TR. In order to evaluate the energy performance of St. Pierre Han, BEP-TR is used. This methodology is applicable for both new and existing buildings, including residential buildings, office buildings, educational facilities, health care buildings, hotels, and shopping centers. BEP-TR calculates net energy demand for heating and cooling of the building, total energy consumption of the building considering the losses and system efficiencies of the installed systems, energy consumption for ventilation, lighting regarding the daylight effect and energy consumption for sanitary hot water. BEP-TR is a web-based application. Due to the limitations of the web-based software, the calculation method is applicable to seven major geometrical forms of buildings. These are rectangle form, L-form, T-form, U-form, +-form, courtyard and double rectangle form (Figure 4.8). Each floor is taken as a separate zone, due to the changes in shading factors, solar incident angles; however, the set point temperatures, internal heat gains and mechanical systems are constant. The *han* building is considered to have a L-form (Figure 4.9).

Figure 4.10: Geometrical forms in BEP-TR.



Source: Edited by Dila Vural.

Figure 4.11: St. Pierre Han’s plan in L-form for BEP-TR evaluation.



Source: Personal photograph.

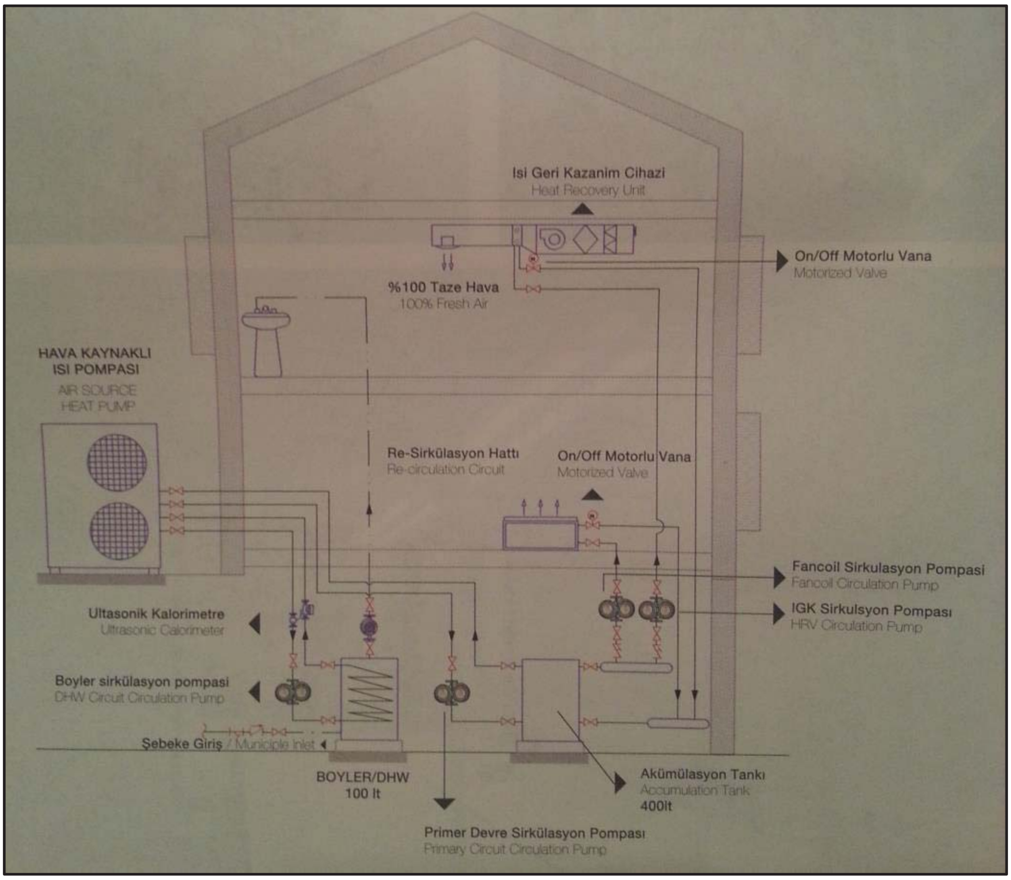
Insulation of the building envelope from inside plays an important role in thermal efficiency and energy saving. Regarding the historic value of the *han* building, the insulation can only be installed from inside. Regarding insulation types, there are two of them that are suggested for the case building. These consist of expanded polystyrene (EPS) and extruded polystyrene (XPS). EPS and XPS are recyclable products that support LEED points. They are resistant to moisture and have a stable R-value. A layer of 5-8 cm EPS or a layer of 3-4 cm XPS is suitable for the thick walls of St. Pierre Han. A thick layer of rockwool insulation (12-15 cm) is suggested under the roof because heat loss is at the highest there.

As low/zero carbon technologies, photovoltaic panels may be installed on the freestanding roof area of St. Pierre Han and possible two credit points can be earned under the category of green power (Figure 4.12). They also help to reduce heat island effect by covering roof with reflective coatings, which absorb the sunlight and prevent it from warming the building. Solar power helps to reduce building’s electricity needs by collecting sunlight and converting it to electric power. Istanbul’s climatic conditions are suitable and effective for benefiting from solar power. A grid tile system can combine the photovoltaic panel system with the air based heat pump system. An air based heat pump works as a heat exchanger, which absorbs outdoor air energy to use in building's heating and cooling as in domestic hot water preparation (Figure 4.14). In this case, an air-based heat pump can be used in heating, cooling and domestic hot water preparation of St. Pierre Han (Figure 4.13). The high coefficient of performance (COP) ratio (3-4) and inverter compressor technology of the air-based heat pump minimizes the energy consumption of the building. Fossil fuel shouldn't be used and low capacity refrigerant needs to be used in the heat pump system. In LEED certification system, photovoltaic panels can help to gain seven points in on-site renewable energy credit. Also, they can achieve extra points in optimizing energy performance. According to evaluation results of the reference building in BEP-TR, renewable energy utilized in photovoltaic panels on the 800 square meter roof area refers to 265,3 percent. Due to the large roof area, the percentage is high. If only 50 square meter of the roof is covered with panels, 200 kilowatt of energy can be achieved, which can supply the entire energy demand of the *han* building.

Figure 4.12: Photovoltaic panels installed on roof

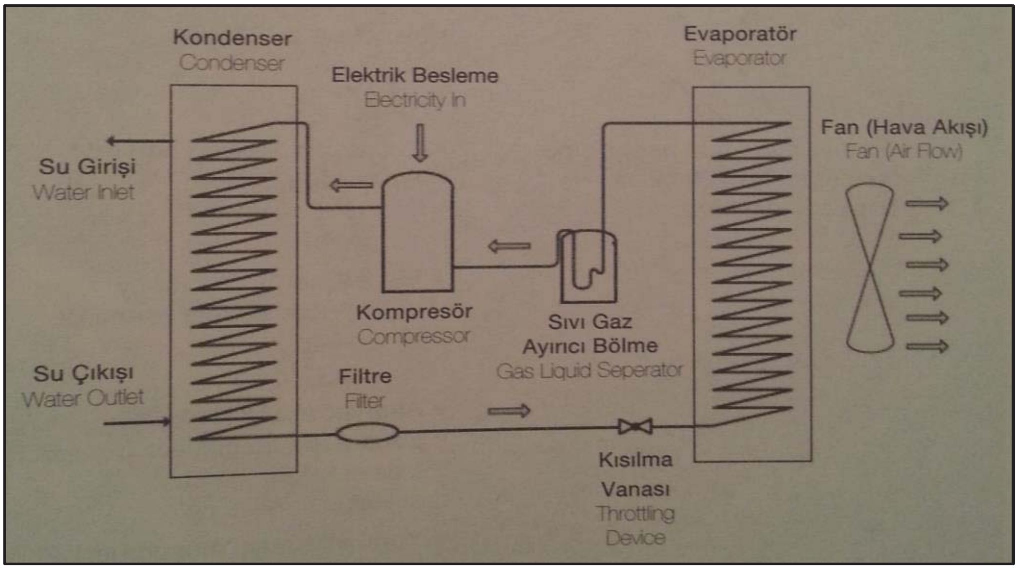
Source: http://www.pmsilicone.com [Accessed 20 December 2014]

Figure 4.13: Mechanical system with an air-based heat pump



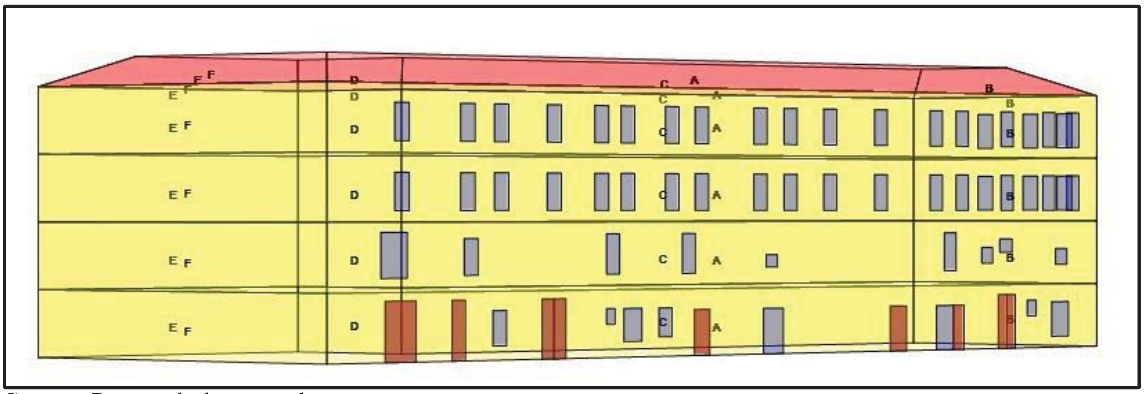
Source: ERKE Green Academy, p.24.

Figure 4.14: Principle of an air-based heat pump



Source: ERKE Green Academy, p.25.

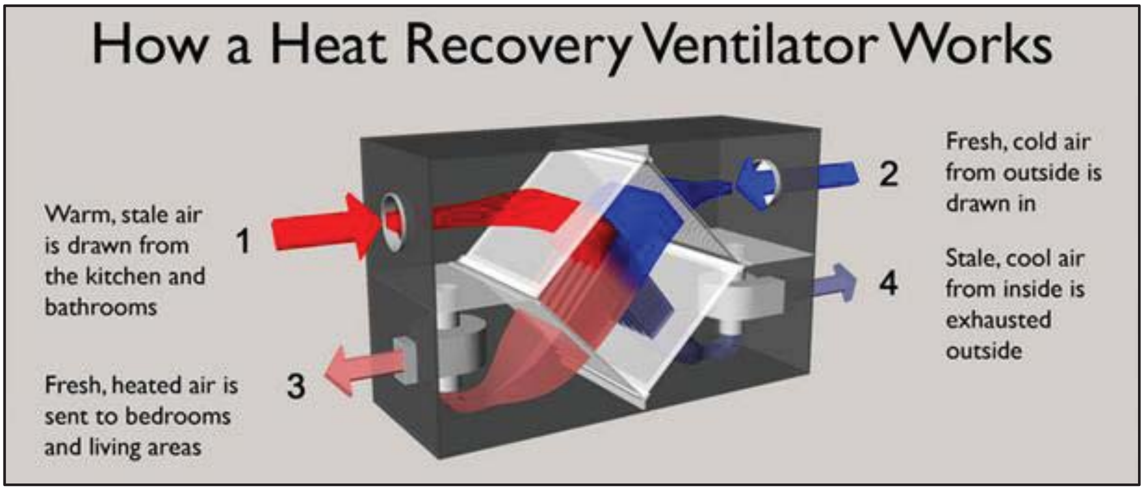
Figure 4.15: Case study building in BEP-TR.



Source: Personal photograph.

A heat recovery ventilation system, as an instance EcoV, can be used in the building regarding its high efficiency heat exchanger, bypass ventilation, strong filter function and flexibility of installation. This system is also a component recommended by Passivhaus Institute. Natural ventilation is suggested for small rooms with low density in the *han* building. By comparing the current case study building with the reference renovated building, 14 percent energy saving is evaluated in BEP-TR and four points are possible to earn in optimizing energy performance credit.

Figure 4.16: Principle of a heat recovery ventilator



Source: http://thetyee.ca/News/2011/01/25/Passivhaus/ [Accessed 20 December 2014]

Figure 4.17: Evaluation results of the current building in BEP-TR.

T.C.
ÇEVRE VE ŞEHİRCİLİK
BAKANLIĞI

ENERJİ KİMLİK BELGESİ
HESAPLAMA SONUÇ FORMU

Proje Kodu : 308054

Proje Adı : St. Pierre Han
Kapalı Kullanım Alanı : 2.862,36
Ada/Pafta/Parsel : 162/106/46
Adres : Beyoglu Ilçesi Bereketzade Mh. Eski Banka Sk.
İl : ISTANBUL
İlçe : Beyoglu
Belediye : Beyoglu
Bina Yapılış Tarihi :
Bina Yenileme Tarihi :
Bina Tipi : Ofis
Bina Sahibinin Adı : St. Pierre Han
Bina Sahibinin Adresi : Beyoglu Ilçesi Bereketzade Mh. Eski Banka Sk.

SORUMLU FİRMANIN
Firma Kodu : F34W8395
Ünvanı : BIR Muhendislik ve Danismanlik San. Ve Tic. Ltd. Sti.
Adresi : Kisikli Mah. Alemdag Cd. Comert Sk. No:5/3 Uskudar
Şehir : ISTANBUL
Telefon / Faks : 2163442070
Vergi dairesi : UMRANIYE
Vergi numarası : 1770307506

SORUMLU EKB UZMANININ
Adı Soyadı : Cengiz BULUT
Uzman sertifika no'su : EGT-0173
Sertifika veriliş tarihi : 09.12.2014
Adresi : Maresal Çakmak Mah. Ogretici Sk. No:9/8 Gungoren
Telefonu : 05071871372 05313589040

ENERJİ KİMLİK BELGESİ DEĞERLERİ

Enerji kullanım alanı	Kullanılan sistem	Nihai tüketim (kWh/yıl)	Birincil tüketim (kWh/yıl)	m^2 başına tüketim	SINIFI
TOPLAM		351.572,81	790.773,46	122,83	B
Isıtma	Isitma Sistemi, Isitma Sistem	154.057,96	363.576,80	53,82	B
Sıhhi Sıcak Su	Sicak Su Sistemi, Sicak Su Sis	28.631,16	28.631,16	10,00	B
Soğutma	Sogutma Sistemi, Sogutma Si	106.081,86	250.353,18	37,06	B
Havalandırma		0,00	0,00	0,00	
Aydınlatma		62.801,83	148.212,32	21,94	B
Sera Gazı Emisyonu				91,94	C

Yenilenebilir Enerji Kullanım Oranı	%0,00

Source: Personal photograph.

Figure 4.18: Evaluation results of the renovated building in BEP-TR.

T.C.
ÇEVRE VE ŞEHİRCİLİK
BAKANLIĞI

ENERJİ KİMLİK BELGESİ
HESAPLAMA SONUÇ FORMU

Proje Kodu : 308094

Proje Adı : St. Pierre Han Yalitimli
Kapalı Kullanım Alanı : 2.862,36
Ada/Pafta/Parsel : 162/ 106 /46
Adres : Beyoglu Ilçesi Bereketzade Mh. Eski Banka Sk.
İl : ISTANBUL
İlçe : Beyoglu
Belediye : Beyoglu
Bina Yapılış Tarihi :
Bina Yenileme Tarihi :
Bina Tipi : Ofis
Bina Sahibinin Adı : St. Pierre Han Yalitimli
Bina Sahibinin Adresi : Beyoglu Ilçesi Bereketzade Mh. Eski Banka Sk.

SORUMLU FİRMANIN
Firma Kodu : F34W8395
Ünvanı : BIR Muhendislik ve Danismanlik San. Ve Tic. Ltd. Sti.
Adresi : Kisikli Mah. Alemdag Cd. Comert Sk. No:5/3 Uskudar
Şehir : ISTANBUL
Telefon / Faks : 2163442070
Vergi dairesi : UMRANIYE
Vergi numarası : 1770307506

SORUMLU EKB UZMANININ
Adı Soyadı : Cengiz BULUT
Uzman sertifika no'su : EGT-0173
Sertifika veriliş tarihi : 09.12.2014
Adresi : Maresal Cakmak Mah. Ogretici Sk. No:9/8 Gungoren
Telefonu : 05071871372 05313589040

ENERJİ KİMLİK BELGESİ DEĞERLERİ

Enerji kullanım alanı	Kullanılan sistem	Nihai tüketim (kWh/yıl)	Birincil tüketim (kWh/yıl)	m² başına tüketim	SINIFI
TOPLAM		304.409,73	501.909,97	106,35	B
Isıtma	Isitma Sistemi, Isitma Sistem	125.118,44	125.118,44	43,71	B
Sıhhi Sıcak Su	Sicak Su Sistemi, Sicak Su Sis	34.070,53	34.070,53	11,90	C
Soğutma	Sogutma Sistemi, Sogutma Si	110.330,86	260.380,83	38,55	B
Havalandırma		0,00	0,00	0,00	
Aydınlatma		34.889,91	82.340,18	12,19	B
Sera Gazı Emisyonu				62,08	C

Yenilenebilir Enerji Kullanım Oranı	%265,3

Source: Personal photograph.

4.2.3.1 Evaluation result of St. Pierre Han in the scope of energy & atmosphere concepts

In energy and atmosphere concept, 35 possible points can be earned, but the building can earn four points regarding the optimization of energy performance criteria and potential 16 points if the advices given are implemented to the project. Interior insulation of the building's roof and walls combined together with efficient mechanical systems contribute to the reduction of energy demand and costs. Also, the evaluation results of energy simulation in BEP-TR shows that the existing historic *han* building can achieve a B-class certificate which proves that the old building is already sustainable and green.

Table 4.3: Energy and atmosphere concepts evaluation result

CREDIT CATEGORY	CREDIT	EARNED CREDIT	POTENTIAL CREDIT
Optimize Energy Performance	1-19	4	-
On-site Renewable Energy	1-7	-	7
Enhanced Commissioning	2	-	2
Enhanced Refrigerant Management	2	-	2
Measurement & Verification	3	-	3
Green Power	2	-	2
Overall Evaluation	**35**	**4**	**16**

Source: Edited by Dila Vural.

4.2.4 Materials & Resources Concepts

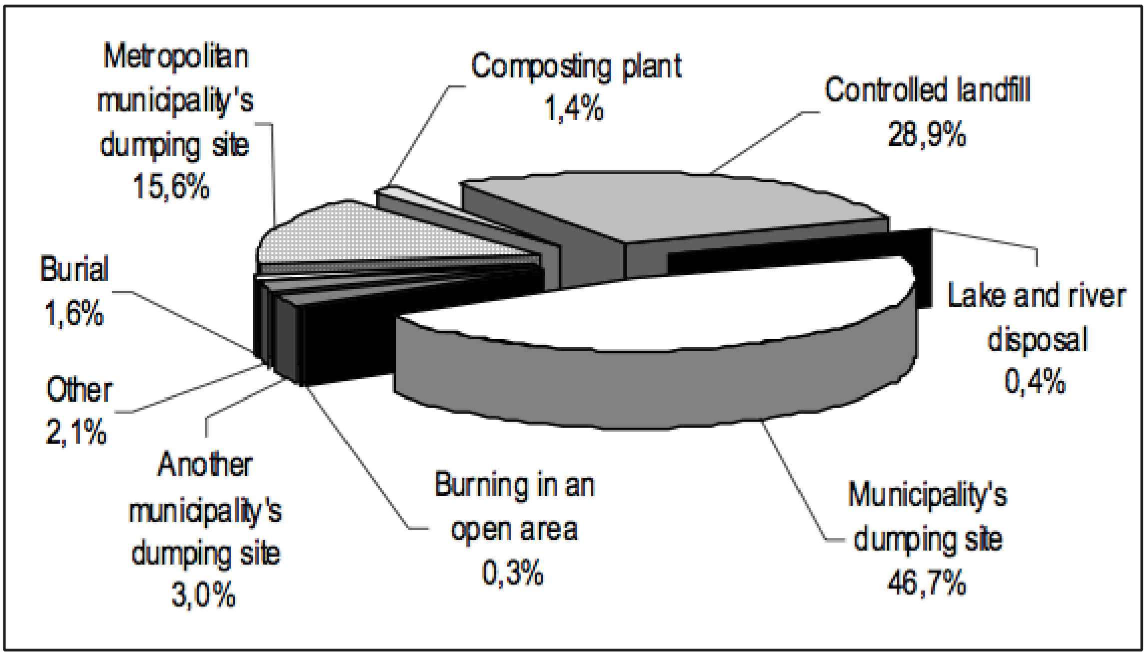
Environmentally friendly construction practices earn credits in the LEED category of materials and resources. Within the scope of materials and resources concepts, the project can gain 14 credit points under the condition that the prerequisite of storage and collection of recyclables is fulfilled. The first step is to provide easily accessible, dedicated area for collection and storage of recycled materials for the entire building. This must include paper, cardboard, glass, plastics and metals. Recyclable waste bins located to the circulation areas of the *han* building, as key elements for reduction of waste generation, fulfill the single prerequisite of this category. These bins, made out of recycled steel material, will collect paper, cardboard, glass, plastic and metal, and can be reused many times. Assessment of the project under eight credit categories aims to increase the amount of recyclable building materials, examine re-use of waste and support use of regional materials.

Figure 4.19: Recyclable waste bins

Source: http://www.quickenloans.com [Accessed 20 December 2014]

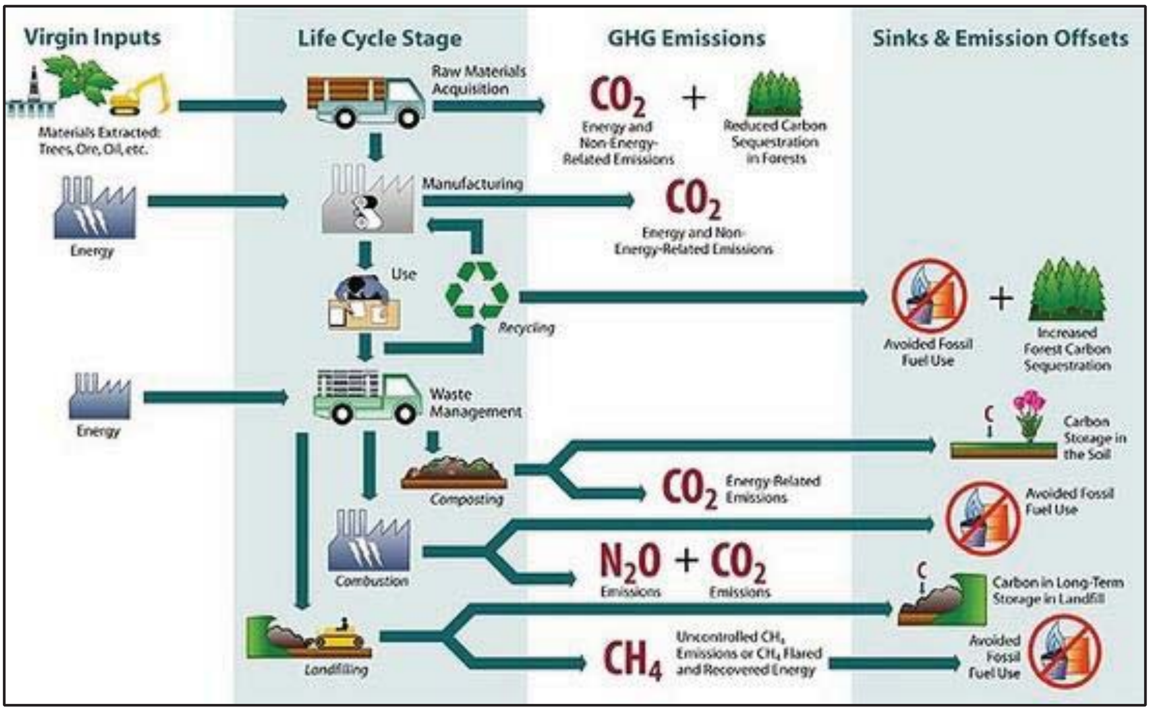
The aim of this credit category is to divert and re-use waste as to reduce waste generation. Construction waste management includes two credit points for the project. A waste management plan can make possible that up to 75 percent of the construction and demolition debris be reclaimed and recycled. This not only contributes to the nature, but also saves energy spent for recycling of for example metallic and plastic packages and is an essential aspect of sustainable building. So, the construction waste management plan should follow the Regulation on the Control of Excavated Soil, Construction and Debris Waste carried out by the Ministry of Environment and Forestry in Turkey. Some materials of the case study building can be reused. For instance, doors, windows, woodwork and plank flooring might substitute for new products.

Figure 4.20: Disposal methods in Turkey



Source: Turkish Statistical Institute, http://www.sayistay.gov.tr. [Accessed 20 December 2014]

Figure 4.21: Waste management recycling



Source: http://www.wastemanagementrecycling.net [Accessed 20 December 2014]

In this renovation project, structural and interior nonstructural elements can be reused in order to prevent waste. Using existing interior non-structural elements in at least 50 percent of the completed building brings a credit point. To earn up to three credit points, existing structure and envelope including walls, floors and roof of St. Pierre Han can be maintained and reused. To minimize materials impact, materials with less lifecycle can be selected; salvaged, refurbished or reused materials can be used. The original structure should be preserved and low maintenance, long-life products should be chosen for the project to reduce the energy and costs of maintaining and replacing materials. Locally manufactured, harvested and extracted materials earn possible two points. As a result, more than 20 percent of materials can have recycled content and be manufactured within 800 km of the site. One possible point can be earned for two and a half percent rapidly renewable material by cost. Possible two points can be earned according to the rate of recycled content use in the building. Wood is among the most sustainable building materials. The requirements for the credit is to use a minimum of 50 percent (based on cost) of wood based materials and products that are certified by FSC. The wood used in the renovation of the *han* building can be certified by the FSC, which means that it was sustainably managed. The continued use of the building will also promote sustainable materials and resource use.

Figure 4.22: Site location map for providing regional materials

Source: Google Maps [Accessed 20 December 2014]

4.2.4.1 Evaluation result of St. Pierre Han in the scope of materials & resources concepts

In materials and resources concept, 14 possible points can be earned, but the building can only earn four points with the current situation and potential ten points if the advices given are implemented to the project. Preserving the existing shell and interior walls drives to the need for fewer new materials. Materials selection plays a significant role in green retrofitting projects. The project team can maximize the use of recycled construction waste and select new materials regarding their recycled content, regional origin, rapidly renewable features and low chemical emissions. For instance, cork material and laminated flooring with their environmentally friendly and sustainable features might be suggested on commonly used rooms. Cork is extracted cyclically from the cork oak tress without damaging them and does not reveal toxin substances during its production process. Additionally, at least 50 percent certified wood might be used in place of the old wood structures in the *han* building.

Table 4.4: Materials and resources concepts evaluation result

TITLE	CREDIT	EARNED CREDIT	POTENTIAL CREDIT
Building Reuse: Maintain Existing Walls, Floors, Roof	1-3	3	-
Building Reuse: Maintain Interior Nonstructural Elements	1	1	-
Construction Waste Management	1-2	-	2
Materials Reuse	1-2	-	2
Recycled Content	1-2	-	2
Regional Materials	1-2	-	2
Rapidly Renewable Materials	1	-	1
Certified Wood	1	-	1
Overall Evaluation	**14**	**4**	**10**

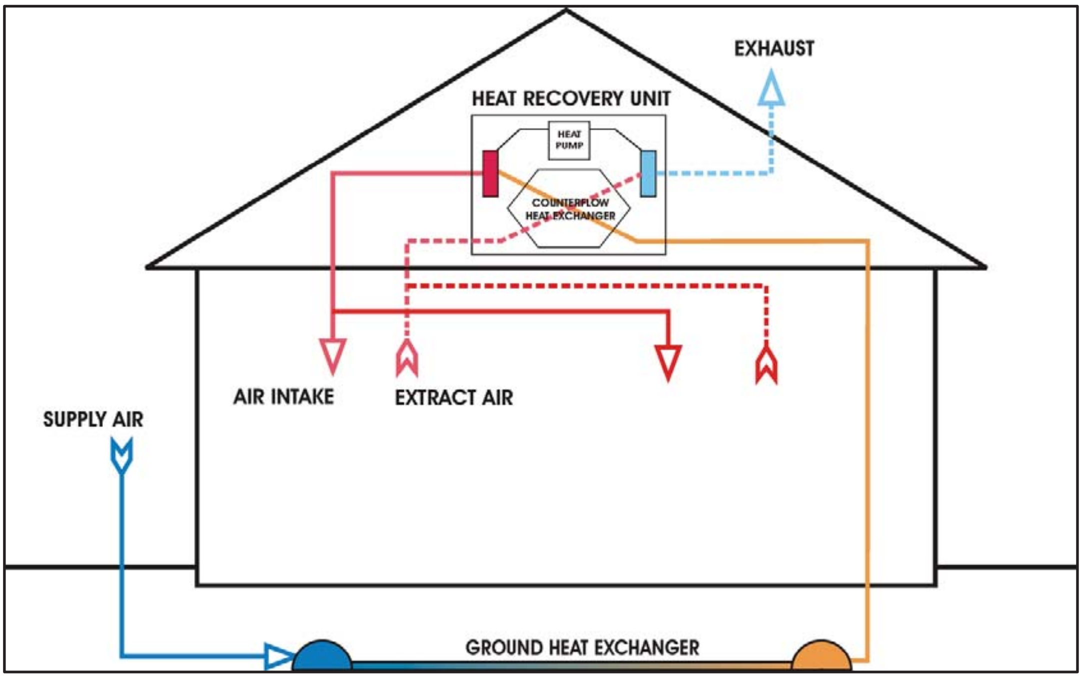
Source: Edited by Dila Vural.

4.2.5 Indoor Environmental Quality Concepts

The concepts of indoor environmental quality reward decisions made about indoor air quality, thermal and visual comfort and occupants' satisfaction with two prerequisites and 15 key considerations each with one credit points. Minimum indoor air quality performance and Environmental Tobacco Smoke (ETS) Control are to be fulfilled for the assessment. Smoking is not allowed in the building and within eight meters of entries as designated smoking rooms that contains, captures and removes ETS are to be provided. Building products that are used in the building mostly contain compounds which have a negative impact on indoor air quality. By using low-emitting materials in the renovation project, sustainable strategies are achieved and credit points are earned in the scope of LEED. The skylights and the passive ventilation system play a key role in this category. Passive ventilation system ensures that comfortable, clean air is always circulated through the building. Low VOC paints, adhesives, finishes and fabrics can be used throughout the *han* building to ensure that indoor air quality remains high. Carbon dioxide monitoring and demand-controlled ventilation can also ensure a healthy environment and earn possible one credit point to the project. Advanced glazing and skylights bring daylight deep into the *han* building and ensure that occupants are connected to the outdoors. It is proven that high-quality indoor environments increase productivity. To achieve this, the project team must control thermal comfort, consider acoustics, ensure lighting satisfaction, and provide daylight and views. High indoor thermal comfort can be achieved with monitoring and controlling of the relevant system.

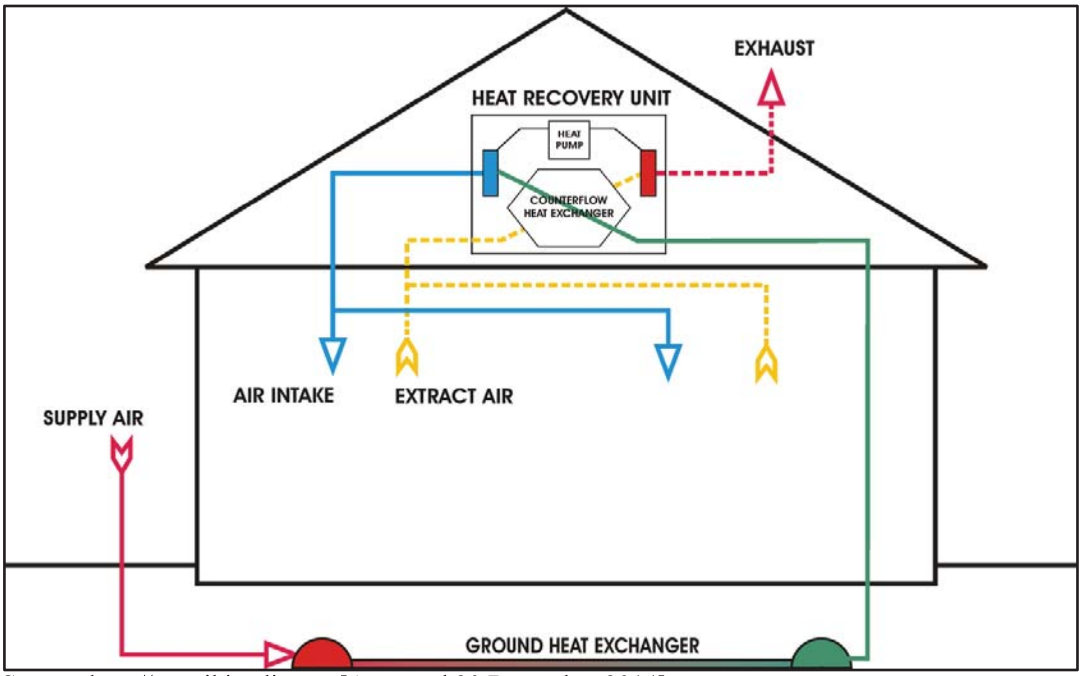
Outdoor air delivery monitoring is one of the credit categories with one point that request, in case of mechanical ventilation, monitoring of CO_2 concentrations within all regularly occupied spaces and measuring of the direct outdoor airflow. In case of natural ventilation, monitoring CO_2 concentrations within each space is required. It is suggested that small rooms are naturally ventilated and other rooms with a high density are mechanically ventilated with a heat recovery ventilator. This system provides fresh air and an improved climate control as it also helps saving energy by reducing heating and cooling demand of the building.

Figure 4.23: Heating process with heat pump and ground heat exchanger



Source: http://en.wikipedia.org [Accessed 20 December 2014]

Figure 4.24: Cooling process with heat pump and ground heat exchanger



Source: http://en.wikipedia.org [Accessed 20 December 2014]

In case of mechanical ventilation, each outside air intake must be modified; ventilation distribution system or air fan must be supplied. In case of natural ventilation, the requirements for location and size of ventilation openings must be provided according to ASHRAE 62.1-2007 standards. Natural ventilation can be provided through operable windows and skylights.

The "sick building syndrome" is a common problem that many older buildings suffer. This situation caused by inadequate ventilation, chemical substances from indoor and outdoor sources or biological substances such as mold is regarded as the experience of acute health and comfort problems that appear in building's occupants. In order to prevent the sick building syndrome, the choice of materials used in the building (adhesives and sealants, paints and coats, flooring systems, composite wood and agrifiber products, furniture and furnishings, ceilings and wall systems) is crucial. The chosen materials should emit zero or low levels of VOCs in order to prevent the vaporization of harmful compounds at room temperature, which is called the off-gassing process. Paints and coatings used on interior of building must comply with VOC content limit requirements of reference standards based on project scope.

Table 4.5: Acceptable maximum VOC values for paints and coatings

IEQ 4.2 Paints and Coatings - Request for grouping by customer			
Paints and coatings used on the interior of the building (i.e. inside of the weatherproofing system and applied on-site) shall comply with the following criteria as applicable to the project scope			
Architectural paints and coatings		**Other coatings**	
applied to interior walls and ceilings			
Architectural paints and coatings applied to interior walls and ceilings shall not exceed the volatile organic chemical (VOC) content limits established in Green Seal Standard GS-11, Paints, First Edition, May 20, 1993.		Clear wood finishes, floor coatings, stains, primers, and shellacs applied to interior elements shall not exceed the VOC content limits established in South Coast Air Quality Management District (SCAQMD) Rule 1113, Architectural Coatings, rules in effect january 1, 2004	
GS-11, May 1993:		**Other coatings**	**VOC level (in g/L)**
Product Type	**VOC limit (in g/L)**	*- Rule 1113, Jan 1, 2004*	(VOC = volatiles less water)
	(VOC = volatiles less water)	Clear wood finishes	350
- Interior:		Varnish	350
Flat Topcoat	50	Sanding Sealers	350
Non-Flat Topcoat	150	Lacquer	550
		Floor coatings	100
Anti-corrosive paints and coatings		Stains	250
Anti-corrosive and anti-rust paints applied to interior ferrous metal substrates shall not exceed the VOC content limit of 250 g/L established in Green Seal Standard GC-03, Anti-Corrosive Paints, Second Edition, January 7, 1997.		Clear Primers	200
GC-03, Jan. 1997:		Shellacs	
Anti-corrosive Paints	**VOC level (in g/L)**	Clear	730
	(VOC = volatiles less water)	Pigmented	550
Gloss	250		
Semi-gloss	250		
Flat	250		
Explanation - "g/L minus water" is calculated after this formula:			
- normal case:			
= ([g all volatiles] - [g water] - [g exempt compounds]) / ([l material] - [l water] - [l exempt compounds])			
- or for products with less than 120 g/l solids:			
= ([g all volatiles] - [g water] - [g exempt compounds]) / [l material]			
For comparison - EU Decopaint Directive, VOC % w/w calculation			
= [kg VOC] x 100 / [kg material]			

Source: http://www.eurofins.com [Accessed 20 December 2014]

Table 4.6: Acceptable maximum VOC values for adhesives and sealants

IEQ 4.1 Adhesives and Sealants - Request for grouping by customer			
Adhesives, Sealants and Sealant Primers shall comply with South Coast Air Quality Management District (SCAQMD) Rule #1168. Volatile organic compound (VOC) limits listed in the table below correspond to an effective date of July 1, 2005			
This needs either calculation from formula, or testing.			
Architectural Applications	**VOC Limit [g/L less water]**	**Substrate Specific Applications**	**VOC Limit [g/L less water]**
Indoor Carpet Adhesives	50	Metal to Metal	30
Carpet Pad Adhesives	50	Plastic Foams	50
Wood Flooring Adhesives	100	Porous Material (except wood)	50
Rubber Floor Adhesives	60	Wood	30
Subfloor Adhesives	50	Fiberglass	80
Ceramic Tile Adhesives	65		
VCT & Asphalt Adhesives	50	**Sealants**	**VOC Limit [g/L less water]**
Drywall & Panel Adhesives	50	Architectural	250
Cove Base Adhesives	50	Nonmembrane Roof	300
Multipurpose Construction Adhesives	70	Roadway	250
Structural Glazing Adhesives	100	Single-Ply Roof Membrane	450
		Other	420
Specialty Applications	**VOC Limit [g/L less water]**		
PVC Welding	510	**Sealant Primers**	**VOC Limit [g/L less water]**
CPVC Welding	490	Architectural Non Porous	250
ABS Welding	325	Architectural Porous	775
Plastic Cement Welding	250	Other	750
Adhesive Primer for Plastic	550		
Contact Adhesive	80	**Aerosol Adhesives**	**VOC weight [g/L less water]**
Special Purpose Contact Adhesive	250	Aerosol Adhesives must comply with Green Seal Standard for Commercial Adhesives GS-36 requirements in effect on October 19, 2000.	
Structural Wood Member Adhesive	140	General purpose mist spray	65% VOCs by weight
Sheet Applied Rubber Lining Operations	850	General purpose web spray	55% VOCs by weight
Top & Trim Adhesive	250	Special purpose aerosol adhesives (all ty	70% VOCs by weight
Explanation - "g/L minus water" is calculated after this formula:			
- normal case:			
= ([g all volatiles] - [g water] - [g exempt compounds]) / ([l material] - [l water] - [l exempt compounds])			
- or for products with less than 120 g/l solids:			
= ([g all volatiles] - [g water] - [g exempt compounds]) / [l material]			
For comparison - EU Decopaint Directive, VOC % w/w calculation			
= [kg VOC] x 100 / [kg material]			

Source: http://www.eurofins.com [Accessed 20 December 2014]

The intent of daylight and views category is to connect building occupants with the outdoors, reinforce circadian rhythms and reduce the use of electrical lighting. The controllability of lighting category requires providing individual lighting controls for 90 percent of occupants; provide lighting system controllability for all shared multi-occupant spaces. Controllability of thermal comfort requires providing individual comfort controls for 50 percent of building occupants and for all shared multi-occupant spaces. Daylight with a minimum of 100 lux in 75 percent of occupied spaces earns one point. In order to get one more point, direct line of sight to outdoor environment via vision glazing between 76 cm and 230 cm above finish floor for building occupants in 90 percent of all regularly occupied areas must be achieved. Skylights also help daylight to introduce into the rooms of the *han* building. Window to floor ratio (WFR) and the visible light transmittance (VLT) of windows for 71 percent helps to measure the ylight in the building following the criteria: *(0,15 < VLT x WFR < 0,18)*. The result is between specified intervals and fulfills the criteria set fort by LEED.

Figure 4.25: Skylights of the *han* building

Source: http://www.envanter.gov.tr/anit/kentsel/galeri [Accessed 20 December 2014]

Figure 4.26: Skylights from inside of the *han* building

Source: http://www.envanter.gov.tr/anit/kentsel/galeri [Accessed 20 December 2014]

Figure 4.27: Ground floor plan of St. Pierre Han

Source: Halil Onur-Ali Çiçek Mimarlık, 2012

Figure 4.28: First floor plan of St. Pierre Han

Source: Halil Onur-Ali Çiçek Mimarlık, 2012

Figure 4.29: Second floor plan of St. Pierre Han

Source: Halil Onur-Ali Çiçek Mimarlık, 2012

Table 4.7: Window to floor ratio (WFR) of the second floor

Permanently Used Rooms	Floor Area (m^2)	Window Area (m^2)	WFR
1	17,5	4,4	0,25
2	37,7	4,4	0,12
3	23,7	6	0,25
4	26,8	-	0
5	10,7	3	0,28
6	23,4	6	0,3
7	14	3	0,2
8	18,6	4,4	0,2
9	19,8	4,4	0,2
10	28,5	4,4	0,15
11	36,9	4,4	0,12
12	16,8	4,4	0,3
13	9,8	2,2	0,2
14	10	3	0,3
15	19,8	12	0,6
16	10	4	0,4
Total	**324**	**70**	**0,22**

Source: Edited by Dila Vural.

Figure 4.30: Third floor plan of St. Pierre Han

Source: Halil Onur-Ali Çiçek Mimarlık, 2012

Table 4.8: Window to floor ratio (WFR) of the third floor

Permanently Used Rooms	Floor Area (m^2)	Window Area (m^2)	WFR
1	16,5	4,4	0,3
2	27,1	7	0,3
3	26,5	5	0,2
4	24,4	5	0,2
5	26,2	5	0,2
6	39,2	7	0,2
7	24,5	4,4	0,2
8	60,1	9,2	0,15
9	17,7	4,4	0,25
10	14,8	3	0,2
11	14,2	3	0,2
12	34,7	13,6	0,4
Total	**325,9**	**71**	**0,22**

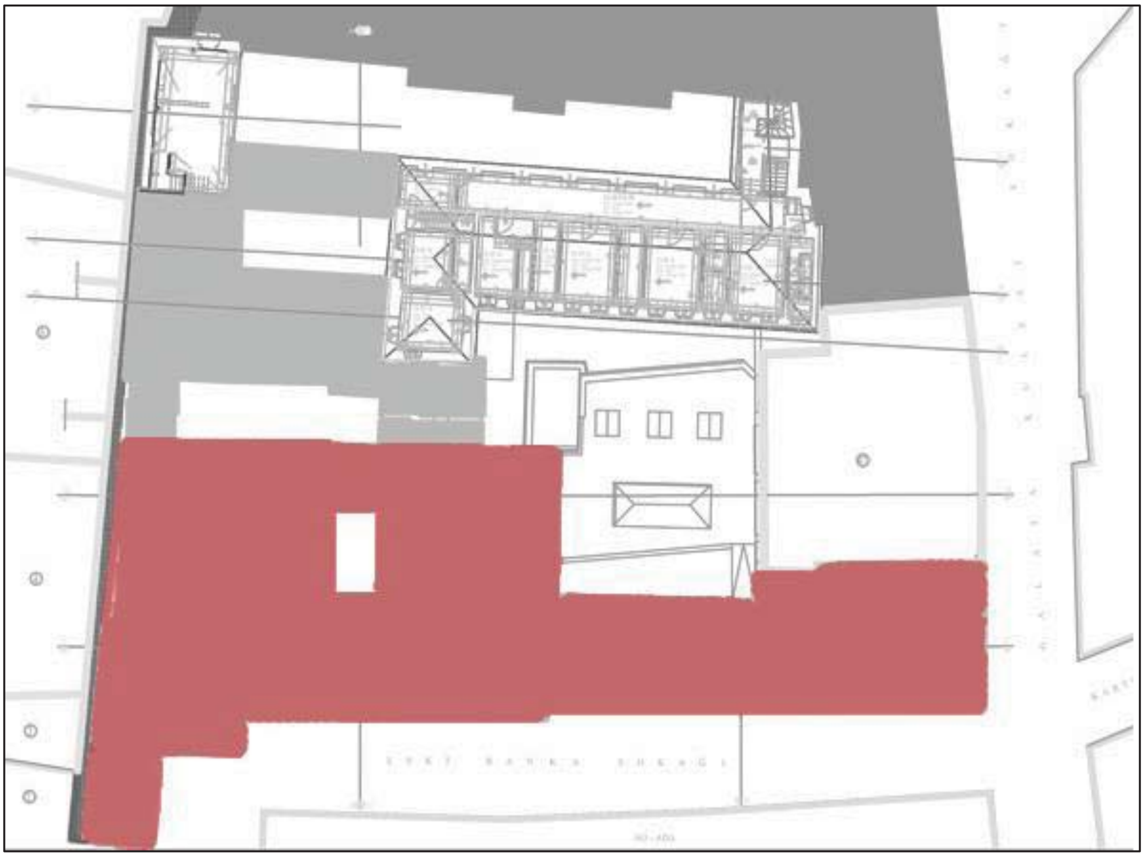
Source: Edited by Dila Vural.

Table 4.9: Calculation of daylight ratio

VLT	0,71
WFR	0,22
VLT x WFR	0,16

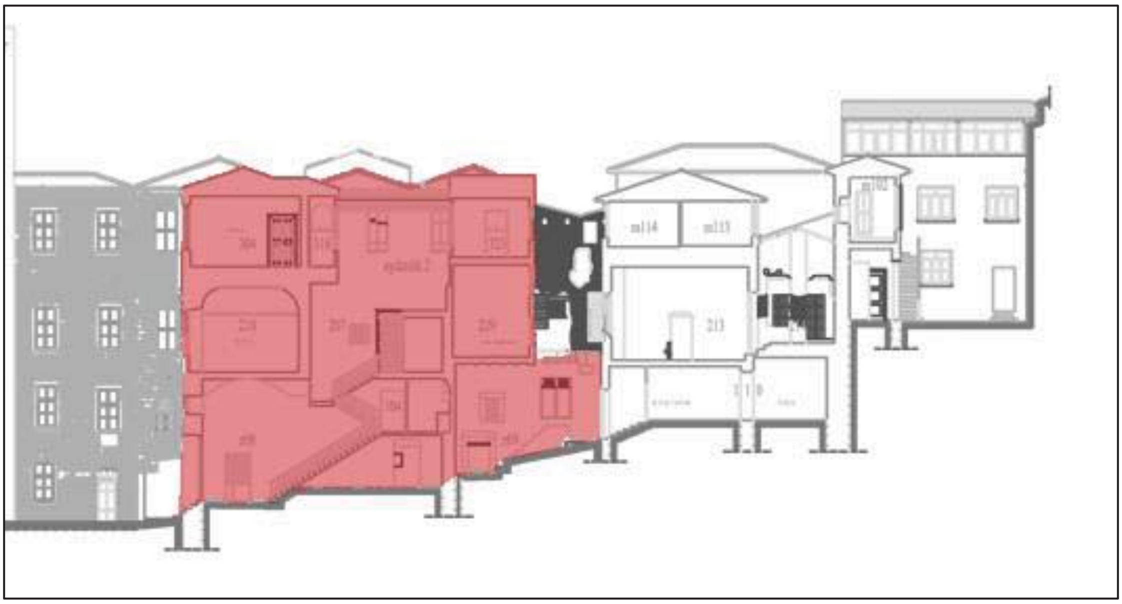
Source: Edited by Dila Vural.

Figure 4.31: Roof plan of St. Pierre Han



Source: Halil Onur-Ali Çiçek Mimarlık, 2012

Figure 4.32: Cross section of St. Pierre Han



Source: Halil Onur-Ali Çiçek Mimarlık, 2012

Figure 4.33: Horizontal section of St. Pierre Han

Source: Halil Onur – Ali Çiçek Mimarlık, 2012

4.2.5.1 Evaluation result of St. Pierre Han in the scope of indoor environmental quality concepts

In indoor environmental quality concepts, 15 possible points can be earned, but the building can only earn two points with its current situation. These categories consist of daylight and views. Potential 13 points can be earned if the advices given are implemented to the project.

Table 4.10: Indoor environmental quality concepts evaluation result

CREDIT CATEGORY	CREDIT	EARNED CREDIT	POTENTIAL CREDIT
Outdoor Air Delivery Monitoring	1	-	1
Increased Ventilation	1	-	1
Construction Indoor Air Quality Management Plan During Construction	1	-	1
Construction Indoor Air Quality Management Plan Before Occupancy	1	-	1
Low-Emitting Materials: Adhesives & Sealants	1	-	1
Low-Emitting Materials: Paints & Coatings	1	-	1
Low-Emitting Materials: Flooring Systems	1	-	1
Low-Emitting Materials: Composite Wood & Agrifiber Products	1	-	1
Indoor Chemical & Pollutant Source Control	1	-	1
Controllability of Systems: Lighting	1	-	1
Controllability of Systems: Thermal Comfort	1	-	1
Thermal Comfort: Design	1	-	1
Thermal Comfort: Verification	1	-	1
Daylight & Views: Daylight	1	1	-
Daylight & Views: Views	1	1	-
Overall Evaluation	**15**	**2**	**13**

Source: Edited by Dila Vural.

4.2.6 Innovation In Design

Within the scope of innovation in design process, six possible points can be earned. A LEED AP should be charged with the project in order to earn a possible point. Green housekeeping is another important issue to improve indoor air quality and achieve healthy ecosystem for health and safety of students, workers and building occupants. Organic or green cleaning is a new trend to avoid toxins and pesticides and encourages cleaning products that are free of toxins and antimicrobials that kill beneficial organisms. Cleaning and laundry products should be non-phosphate, non-toxic, biodegradable and concentrated. LEED AP can also help to find and use certified products, as an instance, Green Seal certification, for effective green housekeeping program. Personal in charge with cleaning needs to be regularly educated.

As an innovation design idea, the project can provide tours of the *han* building during the renovation process and there may be glass walls constructed on *han* rooms and corridors that help to educate visitors and students about how the renovation project achieved a LEED certificate and how this green *han* building works. The green retrofitting and adaptive reuse processes need to be explained and educated to the future generations. Istanbul is a city, which contains many historic structures waiting to be preserved and adaptively reused as a green retrofitting project. The green strategies and the principle of sustainable building may be represented on the walls of St. Pierre Han. The green strategies such as integrated grey water and rainwater-harvesting systems in water use reduction can also gain credit points under the category of innovation in design. Analogically, the high percentage of building materials that are regionally manufactured and harvested brings possible points under innovation in design. The synergies between credit categories bring additional points in LEED rating system.

4.2.6.1 Evaluation result of St. Pierre Han in the scope of innovation in design

In innovation in design concept, six possible points can be earned, but the building cannot earn any points by its current situation. Potential four to five points can be earned if the advices given are implemented to the project. Each innovation is awarded with one point. The project can be awarded with potential points through assigning a LEED AP, educational outreach, green housekeeping, and a high percentage of water use reduction by utilizing rainwater harvesting, stormwater and grey water collecting and reusing systems. A cistern can be placed for the water collecting, recycling and reusing systems and a ground heat exchanger can be installed in the basement floor. Heat exchanger integrated to a heat recovery unit can supply effectively heating and cooling for the building as the rainwater and grey water storing, recycling and reusing systems meet the building's potable as non-potable water need. As a result, these energy and water saving systems achieve points as innovation in design strategies.

Table 4.11: Innovation in design concepts evaluation result

CREDIT CATEGORY	CREDIT	EARNED CREDIT	POTENTIAL CREDIT
Innovation in Design	1-5	-	4
LEED Accredited Professional	1	-	1
Overall Evaluation	**6**	**-**	**5**

Source: Edited by Dila Vural.

4.3 EVALUATION OF ST. PIERRE HAN IN THE SCOPE OF LEED-NC

The case study building, St. Pierre Han in Istanbul, is analyzed according to the criteria set forth by LEED-NC. The evaluation process of the *han* building follows six concepts with the aim to promote healthy, stable, affordable and environmentally friendly practices in building renovation. These concepts consist of sustainable sites, water efficiency, energy and atmosphere, materials and resources, indoor environmental quality, and innovation in design. Projects outside of the U.S. are not eligible for regional priority concepts credits and the case study building in Istanbul cannot gain points from this category.

First of all the project team must create an erosion and sedimentation control plan during the design phase of the project. St. Pierre Han is located on a previously developed site and in a community with a minimum density of 60,000 square feet per acre net. The building is accessible by public transportation and has pedestrian access to a variety of services including bank, laundry, library, school, supermarket, theater, park, pharmacy, restaurant and the post office. Storing bicycle racks, showers and changing areas for employees can encourage bicycle use and reduce pollution and negative land development impacts from automobile use. By providing low-emitting and fuel-efficient vehicles for three percent of full-time equivalent occupants, and by minimizing parking lot in order to limit the use of single occupancy vehicles, five credit points are possible to earn. The categories of brownfield redevelopment, site development by protecting and restoring habitat and maximizing open space cannot earn credit points in this project because more than half of the site is covered with the existing historic building and the structure must be preserved. So, the green area to be planned is limited on the site. The pervious pavement, grid pavers and loose gravel on site can contribute stormwater to return to nature and feed groundwater resources. An open-grid pavement system for at least 50 percent pervious can reduce heat island effect. Rainwater captured from the roof can be used for toilet flushing. Dual-flush toilets, low-flow showerheads and faucets help reducing potable water demand.

An integrated natural and mechanical treatment system to treat stormwater runoff is suggested. This can also bring additional credit points in synergy with innovative wastewater technologies and innovation in design categories. Solar panels that produce energy used to offset nonrenewable resource use can also provide shade and reduce heat island effect on the roof. Suggested technologies to minimize light pollution include full cutoff luminaries, low-reflectance surfaces and low-angle spotlights, which in total gain the project 23 credit points under sustainable sites concepts.

As the second evaluation topic, water efficiency concepts require water use reduction with the aim to increase water efficiency within the building, and to reduce the burden on municipal water supply and wastewater systems. To achieve this, the project team should use high-efficiency fixtures and fixture fittings, and benefit from reusing rainwater, stormwater and grey water. The minimum water saving of 40 percent is equal to potential four credit points. So, the project can earn six points under water efficiency concepts if the given advices are applied.

As the first prerequisite of the energy and atmosphere concepts, fundamental commissioning of building energy systems aims to reduce energy use, lower operating costs, fewer contractor callbacks, provide better building documentation and improve occupant productivity. A whole building energy simulation in BEP-TR fulfills the second prerequisite with the goal to discover the most gainful energy efficiency measures for the retrofitted building. An improvement of 14 percent is demonstrated in the proposed building performance rating for major renovations to existing buildings, compared with the baseline building performance rating. Four credit points are awarded according to the percentage of the improvement. Last but not least, fundamental refrigerant management is required to reduce stratospheric ozone depletion and prevent use of CFC-based refrigerants in HVAC systems.

Photovoltaic panels can be installed on the roof to achieve up to seven points from the credit category of on-site renewable energy and additionally two points under green power. The renewable energy technology must provide at least 35 percent of the building's energy demand. The critical questions in rehabilitation of historic buildings are to whether and how to add insulation to the building's load-bearing, faced stone masonry. If it is a historic building, insulation on the outside is not possible or allowed because of the conflict with the preservation intention. So, the building should be insulated from the inside. The project team can install rockwool panel insulation across the building's low-slope roof and use XPS for the insulation of walls and energy-efficient replacement windows.

Re-using an existing building conserves not only the embodied energy, but also the craftsmanship of the unique, rich and complex structure. The project team can earn points by conserving resources and selecting new materials regarding their regional availability, recycled content and low chemical emissions. In order to reduce the quantity of indoor air contaminants, low-emitting as low-VOC materials should be selected. The original character of the *han* building should be strengthened. As a result of this, the project can gain all points possible under materials and resources concepts.

The concepts of indoor environmental quality intent to contribute to the comfort and well-being of building's occupants. Designed mechanical and natural ventilation systems help to optimize energy efficiency and occupant comfort. As smoking is prohibited in the building, the ventilation air needs to be controlled in designated smoking rooms. A heat recovery unit can be used to minimize the energy consumption associated with higher ventilation rates in mechanically ventilated spaces. Advanced glazing and skylights can improve natural daylight and ventilation. This also can minimize heat loss in wintertime and heat gain in summertime. Skylights provide natural ventilation and increased indoor air quality. Operable windows help for the controllability of thermal comfort. LED light sources with dim availability and presence sensors, which are controlled with automation or by individual occupants, help reduction of light pollution both indoor and outdoor and also save energy. According to manual daylight calculations with the help of WFR and VLT, optimized daylight factors are achieved. All points of this category are achievable if the advices given are implemented to the project.

A LEED AP earns the project a potential credit point in means of supporting and encouraging the design integration required by LEED and educating the project team members about the requirements for application and certification processes. Innovation in design category aims to encourage the design team for an exceptional performance above the requirements addressed by the LEED rating system. For instance, green cleaning is a new trend that supports a healthy environment and can be awarded with a point. As one point is awarded for each innovation achieved, St. Pierre Han can get potential four points regarding the suggested mechanical system consisting of rainwater and grey water re-use systems, a grid tile system of solar power from photovoltaic panels and air-based heat pump, ground heat exchanger and a heat recovery unit. The basement floor of the *han* building is suitable for the storage of the cistern and the ground heat exchanger. Achievements in energy performance and water efficiency through application of exemplary strategies or measures can earn the project up to five credit points under innovation in design concepts.

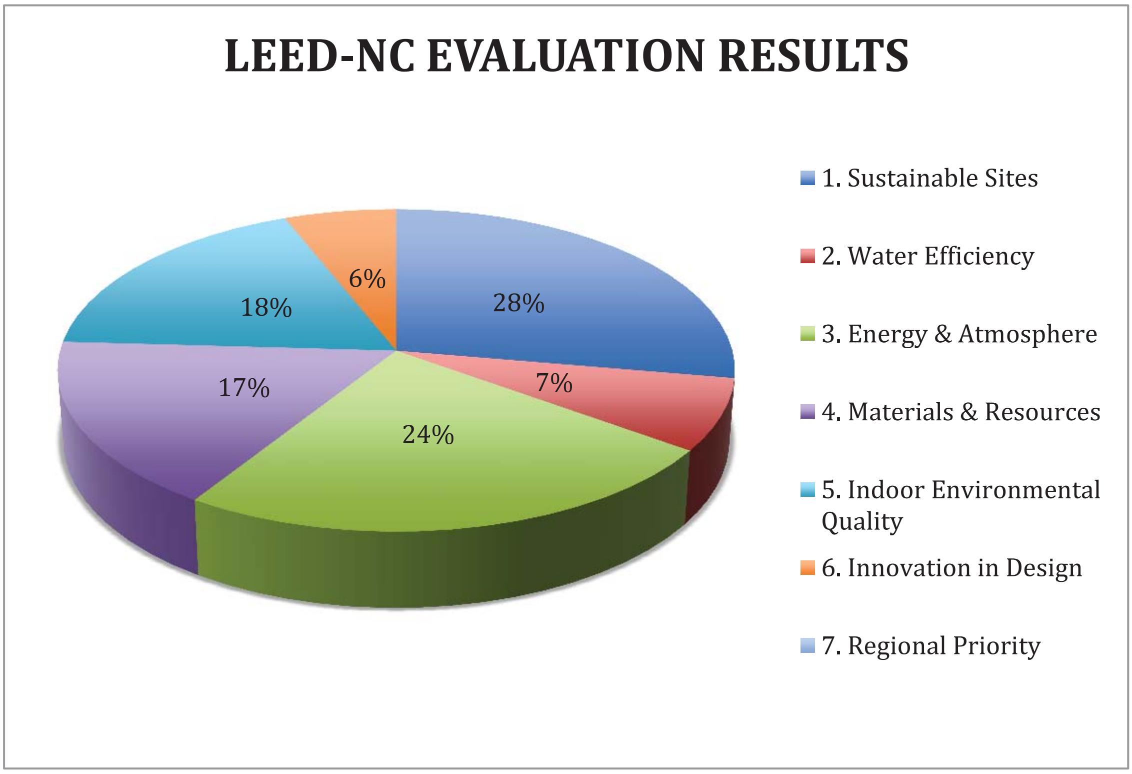
Considering the six concepts of LEED-NC, St. Pierre Han may be a candidate for LEED Platinum certification with 83 credit points. 22 points can be earned with the current situation of the *han* building and 61 potential points are earnable if the advices given are implemented to the project (Table 4.12). The certification process and the certification scale of LEED-NC (Chapter 3.5, p. 48) is explained and shown in the third chapter and the credit results of the table below is certified according to it. Achieved 80 and more points are awarded with a Platinum certificate. According to the percentage distribution of evaluation results, the project earns the highest points respectively under the sustainable sites, energy and atmosphere, indoor environmental quality, materials and resources, water efficiency, and innovation in design concepts (Table 4.13).

Table 4.12: Evaluation results of St. Pierre Han in the scope of LEED-NC

Credit Categories	Points	Earned Points	Potential Points	Total Points
1. Sustainable Sites	26	12	11	23
2. Water Efficiency	10	-	6	6
3. Energy & Atmosphere	35	4	16	20
4. Materials & Resources	14	4	10	14
5. Indoor Environmental Quality	15	2	13	15
6. Innovation in Design	6	-	5	5
7. Regional Priority	4	-	-	-
Total Credit Points:	**110**	**22**	**61**	**83**

Source: Edited by *Dila Vural*

Table 4.13: Percentage distribution of evaluation results



Source: Edited by *Dila Vural*

5. CONCLUSION & RECOMMENDATIONS FOR FUTURE

One of the major issues for our developing world is the subject of sustainable development. The most significant constituents of sustainable development are the building construction and operation, which have irreversible environmental impacts in means of the consumption of raw materials, energy and water, atmospheric emissions and waste generation. Green building certification systems have emerged in order to control and evaluate the environmental impacts of buildings and assess their performance along in a wide range of environmental considerations. Green buildings seek to use land and energy efficiently, conserve water and other natural resources, improve indoor and outdoor air quality, and utilize recycled and renewable materials.

Considering sustainable buildings in the framework of ecology and human health, not only the selection of appropriate technologies, but also the choice of proper materials used in the building are key in conservation of resources and enabling a healthy environment, as buildings are part of the cycle. The materials selected in a sustainable building are preferably obtained from local sources, that has low embodied energy and no production wastes and are easy to maintain, durable, renewable, recyclable and reusable.

As key element in sustainable development, the green preservation and adaptive re-use of existing buildings present excellent opportunities to reduce the energy consumption and CO_2 emissions. Because of this reason, interaction between sustainability and the preservation of heritage buildings has increased within the past decade. So, the strategy to achieve sustainable development should be based around greening the existing building stock rather than building new green buildings.

The preserving of historic structures is a merit to posterity for appraisal of their rich and composite foundation on which modern society has been established. By facilitating green building practices in rehabilitation of historic buildings, not only the aggregation of past and future, but also creation of dynamic places for a social and cultural connection may be possible. Historic buildings, which have a significant degree of sustainability through their careful preservation and adaptive re-use, will reinforce city's cultural and urban identity. Moreover, the promotion of energy efficiency in buildings using sustainable-driven mitigation measures is a key element in ensuring a more sustainable and livable future in cities. Re-using an existing building conserves not only the embodied energy, but also the craftsmanship of the unique, rich and complex structure. St. Pierre Han, which will be adaptively re-used as a cultural arts center, contributes to the understanding of the importance of preserving and greening historic structures.

This study attempts to delineate a roadmap for the implementation of green building rating and certification systems to existing historic buildings in Turkey. LEED-NC rating system can help to shape installation of green strategies for historic buildings undergoing renovations or retrofits. The case study building St. Pierre Han in the Galata district of Istanbul is analyzed by the criteria set forth by the LEED rating and certification system and the energy simulation of the building is studied and advices are given to the project team in order to earn more credits for the building towards credit categories of LEED-NC. The credit earnings through the current state of the building and the situation in which the given advices applied are analyzed.

Within the context of this thesis, the credits earned through the current state of the *han* building are evaluated under the name of "earned credit"; the credits which can be earned in accordance with the building renovation advices to the project team are named "potential credit". The building is analyzed within six credit categories, which consist of sustainable sites, water efficiency, energy and atmosphere, materials and resources, indoor environmental quality, and innovation in design. International projects cannot be evaluated in the scope of the seventh category, which is the regional priority concept and the case study building in Istanbul cannot gain any points from this category.

As the greatest constituent of LEED rating system, energy and atmosphere concepts gain the project four credit points by the current state of the building, and 16 potential points if the advices given are applied. Associated with the increase in energy savings via whole building simulation tools, the building is respected as a greener building. The highest points are earned by the sustainable sites concepts, due to the location and convenient land structure of the building. Regarding their credit categories, 12 points are achieved by the current state of the *han* building as 11 additional points can be achieved after the given advices are applied. As water is gradually becoming more important than it was in the past, it can be accounted of a key element for the sustainability and the green building assessment system and the project can earn six potential points under water efficiency credits. Innovative wastewater technologies can be integrated to the project in order to reduce the amount of potable water use at around 40 percent or more. Within the scope of materials and resources concepts, the project earns four points with the current state and ten potential points associated with the advices implemented to the project in means of recycling and reusing building's materials as selecting rapidly renewable and regional materials for the renovation. The concepts of indoor environmental quality reward decisions made about indoor air quality, thermal and visual comfort and occupants' satisfaction with 15 key considerations each with one credit points. The building earns two points under daylight and views credit categories and 13 potential points if the advices given are implemented to the renovation project. The last evaluation category for the case study, the innovation in design, aims to encourage the design team for an exceptional performance above the requirements addressed by the LEED rating system. Achievements in energy performance and water efficiency through application of exemplary strategies or measures can earn the project up to five potential credit points under innovation in design concepts. In accordance with the evaluation results, the *han* building can become a candidate for a LEED Platinum certificate with 22 earned credit points and 61 potential credit points.

In conclusion, if the advices given are applied to the project, St. Pierre Han can contribute to the significant samples for the preservation and functional adaptability of historic buildings in Istanbul.

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