CONVERTING EXISTING BUILDINGS TO GREEN BUILDINGS: IMPLEMENTATIONS IN TURKEY

by

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IMPLEMENTATIONS IN TURKEY

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ABSTRACT

CONVERTING EXISTING BUILDINGS TO GREEN BUILDINGS: IMPLEMENTATIONS IN TURKEY

Environmental challenges like global warming, climate change and fresh water supply has recently become an important issue. However, humankind continues to harm the nature and waste natural resources. Large amounts of energy consumption and water use all over the world result from buildings and also a large part of human life time is spent in buildings. All these reasons bring green buildings into the front scene that are environmental friendly, sustainable, more comfortable, energy efficient and low consuming structures. Developed countries have a comprehensive knowledge of green building and sustainability concepts and have been working with this awareness for more than 20 years. They established different environmental performance assessment systems. However, there has been lack of awareness in developing countries like Turkey. Since there are thousands of old and inefficient buildings in Turkey's building stock and still a large housing deficit, green building concept is a great opportunity for the country. Since green building is a relatively new concept in Turkey, there are certain questions both in owners' and end users' minds about green building implementations, supplying environmental friendly construction materials, encountering additional costs in a green building project etc. There are many studies about green new construction projects; however there is less information about greening existing buildings. This research is based on investigation of factors influencing green retrofit and renovation projects and the ways in which such projects can be completed efficiently and effectively in Turkey.

ÖZET

MEVCUT BİNALARIN YEŞİL BİNALARA DÖNÜŞTÜRÜLMESİ: TÜRKİYE'DEKİ UYGULAMALAR

Küresel ısınma, iklim değişikliği ve temiz su tedariki son zamanlarda önemli bir sorun haline gelmiştir. Buna rağmen, insanoğlu doğaya zarar vermeye ve doğal kaynakları tüketmeye devam etmektedir. Dünyadaki enerji ve su kullanımının büyük bölümü binalarda gerçekleşmektedir ve ayrıca insanlar hayatlarının çoğunu yine binalarda geçirmektedir. Tüm bu nedenler çevre dostu, sürdürülebilir, daha konforlu, daha verimli ve az tüketen yeşil binaları ön plana çıkarmaktadır. Gelişmiş ülkeler yeşil bina ve sürdürülebilirlik konularında oldukça geniş bilgiye sahipler ve bu bilinçle 20 yıldan fazla bir süredir çalışmalarına devam etmektedirler. Farklı çevresel performans değerlendirme sistemleri oluşturmuşlardır. Ancak; Türkiye gibi gelişmekte olan ülkelerde bu konuda bir bilinç eksikliği görülmektedir. Türkiye'nin yapı stokunda eski ve verimsiz binlerce bina olduğu ve hala büyük bir konut açığı olduğu için, yeşil bina kavramı ülke için büyük bir fırsat teşkil etmektedir. Yeşil bina kavramı henüz Türkiye'de yeni olduğu için, hem mal sahipleri hem de son kullanıcıların akıllarında yeşil bina uygulamaları, çevre dostu malzeme temini ve yeşil bina ek maliyetleri gibi konularda sorular bulunmaktadır. Yeni yeşil bina inşaatları konusunda pek çok bilimsel araştırma bulunmasına rağmen, mevcut binaların yeşil binaya dönüştürülmesi konusunda daha az bilgi mevcuttur. Bu araştırma, yeşil bina dönüşüm projelerini etkileyen etkenleri ve bu projeleri Türkiye'de etkili ve verimli şekilde tamamlamanın yollarını incelemektedir.

TABLE OF CONTENTS

ACKNOWLEDGEMENTS iii

ABSTRACT iv

ÖZET v

LIST OF FIGURES xi

LIST OF TABLES xiii

LIST OF ACRONYMS / ABBREVIATIONS xv

1. INTRODUCTION 1

1.1. Background of the Research 1

1.2. Problem Determination 1

1.3. Problem Statement 2

1.4. Related Studies 3

1.5. Aim and Objectives of the Research 3

1.6. Research Method 4

1.7. Scope and Limitations 5

1.8. Organization of Thesis 5

2. LITERATURE REVIEW 6

2.1. Climate Change and the Remedy: Sustainability 6

2.2. Evolution of Green Buildings 9

2.3. Benefits of Green Buildings 11

2.4. Motivation for Green Design 14

2.5. Cost of Greening 17

2.6. Common Green Building Implementations 19

2.7. Performance of Green Buildings 22

2.8. Government Regulations in the World 23

2.9. Existing Buildings Stock and Green Building Retrofit 25
2.10. Barriers to Adoption of Green Buildings 31
2.11. Development of Green Building Concept in Turkey 34
2.12. International Green Building Performance Assessment Systems 36
3. RESEARCH METHODOLGY 46
3.1. Definition of Case Study 46
3.2. The Case Study as a Research Method 48
3.3. Strengths and Weaknesses of Case Study 50
3.4. Requirements of Case Studies 52
3.5. Sources of Data 54
3.6. Investigated Projects 56
3.7. Research Framework of the Thesis 58
4. CASE STUDIES 62
4.1. Case 1 62
4.1.1. General Information 62
4.1.2. Drivers 62
4.1.3. Resources 63
4.1.4. Tools 64
4.1.5. Barriers 71
4.1.6. Enablers 72
4.1.7. Benefits at Project Level 73
4.1.8. Benefits at Organization Level 78
4.1.9. Lessons Learned 78
4.2. Case 2 79
4.2.1. General Information 79
4.2.2. Drivers 79

4.2.3. Resources 80
4.2.4. Tools 81
4.2.5. Barriers 83
4.2.6. Enablers 84
4.2.7. Benefits at Project Level 85
4.2.8. Benefits at Organization Level 85
4.2.9. Lessons Learned 86
4.3. Case Study 3 87
4.3.1. General Information 87
4.3.2. Drivers 87
4.3.3. Resources 888
4.3.4. Tools 911
4.3.5. Barriers 955
4.3.6. Enablers 99
4.3.7. Benefits at Project Level 100
4.3.8. Benefits at Organization Level 102
4.3.9. Lessons Learned 102
4.4. Case Study 4 104
4.4.1. General Information 104
4.4.2. Drivers 104
4.4.3. Resources 105
4.4.4. Tools 106
4.4.5. Barriers 109
4.4.6. Enablers 110
4.4.7. Benefits at Project Level 111
4.4.8. Benefits at Organization Level 112

4.4.9. Lessons Learned 113
4.5. Case 5 113
4.5.1. General Information 113
4.5.2. Drivers 114
4.5.3. Resources 114
4.5.4. Tools 116
4.5.5. Barriers 118
4.5.6. Enablers 119
4.5.7. Benefits at Project Level 119
4.5.8. Benefits at Organization Level 120
4.5.9. Lessons Learned 120
4.6. Case 6 121
4.6.1. General Information 121
4.6.2. Drivers 121
4.6.3. Resources 122
4.6.4. Tools 123
4.6.5. Barriers 126
4.6.6. Enablers 127
4.6.7. Benefits at Project Level 127
4.6.8. Benefits at Organization Level 128
4.6.9. Lessons Learned 128
4.7. Summary of the Case Studies 128
5. DISCUSSION 132
5.1. General Profile of Green Retrofit and Renovation Projects 132
5.2. Drivers 133
5.3. Resources 134

5.4. Green Implementations 135
5.5. Barriers 139
5.6. Enablers 140
5.7. Benefits at Project Level 141
5.8. Benefits at Organization Level 142
5.9. Lessons Learned 142
6. CONCLUSION 144
6.1. Scope of the Thesis 144
6.2. Conclusions Based on Research Findings 144
6.3. Recommendations for Future Work 146
APPENDIX: AN EXAMPLE OF LEED SCORECARD 147
REFERENCES 148

LIST OF FIGURES

Figure 2.1. Green building milestones between 40's and 80's. 10
Figure 2.2. Green building milestones after 90's. 10
Figure 2.3. Benefits of green buildings. 14
Figure 2.4. Top global business reasons for green buildings. 16
Figure 2.5. Top global social reasons for green buildings. 16
Figure 2.6. Top global environmental reasons for green buildings. 16
Figure 2.7. Information sources to get information on green trends. 17
Figure 2.8. Top green building implementations in the USA. 20
Figure 2.9. Installation and specifications of green products. 21
Figure 2.10. Housing stock change characteristics. 26
Figure 2.11. Green retrofit activities. 28
Figure 2.12. Owners' green retrofit business motivation. 29
Figure 2.13. Environmental motivations for green retrofit projects. 29
Figure 2.14. Most important triggers to green retrofit. 30
Figure 2.15. Challenges to increasing green building activity. 33
Figure 2.16. Challenges to green retrofitting (owners). 34
Figure 3.1. Framework to investigate greening projects in this research. 59
Figure 4.1. White tiles on the roof. 65
Figure 4.2. White roof. 65
Figure 4.3. (a) Recycle bin in the office. 67
Figure 4.3. (b) Waste batteries collection box. 67
Figure 4.4. (a) Sensor faucet. 67
Figure 4.4. (b) Local plants in the garden. 67
Figure 4.5. Heat leakages in the valves. 68

Figure 4.6. Isolation of the valves wrapped with insulating material. 68
Figure 4.7. (a) Old exterior lighting fixtures. 69
Figure 4.7. (b) New exterior fixture. 69
Figure 4.8. LED lamps on the ceiling. 69
Figure 4.9. (a) Ozone friendly gases in use. 70
Figure 4.9. (b) Central air conditioning. 70
Figure 4.10. CO_2 detectors in the garage. 70
Figure 4.11. Mechanical ventilation system on the floors. 70
Figure 4.12. 3 meter long doormat in front of the building. 71
Figure 4.13. (a) Outside view of the hotel. 79
Figure 4.13. (b) The hotel's lateral section. 79
Figure 4.14. (a) Windows. 83
Figure 4.14. (b) Green roof. 83
Figure 4.14. (c) Indoor details. 83
Figure 4.15. (a) Rooms before LEED. 85
Figure 4.15. (b) Stairs before and after LEED. 85
Figure 4.16. (a) Recycle bins on the floors. 92
Figure 4.16. (b) Renewed study hall. 92
Figure 4.17. (a) Atrium before renovation. 95
Figure 4.17. (b) Atrium after renovation. 95
Figure 4.18. CFD model of the atrium. 97
Figure 4.19. Comparison of daily water use according to different standards. 101
Figure 4.20. Comparison of daily energy consumption. 101
Figure 4.21. (a) Façade of Building D. 108
Figure 4.21. (b) Meeting room after LEED. 108
Figure 4.22. (a) Waiting room of the office. 112
Figure 4.22. (b) Entrance hall of Building D. 112

LIST OF TABLES

Table 2.1. Reduction caused by green buildings on environmental impacts. 15

Table 2.2. Common green elements in building development. 21

Table 2.3. Typical barriers for applying green elements in housing projects. ...31

Table 2.4. LEED Rating Systems and Status. 43

Table 3.1. Relevant situations for different research methods. 49

Table 3.2. Complementarity of case studies and statistical methods. 52

Table 3.3. Case study tactics for four design tests. 54

Table 3.4. Project properties that were investigated in the study. 58

Table 3.5. Interviewees that contributed to the study. 58

Table 4.1. LEED scorecard summary of Building A. 64

Table 4.2. Operation and maintenance schedule of Building A. 65

Table 4.3. System data before green building implementations. 74

Table 4.4. System data after green building implementations. 74

Table 4.5. Mechanical systems and their unit types. 75

Table 4.6. Yearly electric consumption rates. 75

Table 4.7. Yearly electric savings. 76

Table 4.8. Yearly gas consumption rates. 76

Table 4.9. Yearly gas savings. 76

Table 4.10. Yearly water use. 76

Table 4.11. Yearly water savings. 77

Table 4.12. Results of employee satisfaction survey. 77

Table 4.13. LEED scorecard summary of Building B. 81

Table 4.14. LEED scorecard summary of Building C. 91

Table 4.15. Internal air test results. 94

Table 4.16. LEED scorecard summary of Building D. 106

Table 4.17. LEED scorecard summary of Building E. 116

Table 4.18. LEED scorecard summary of Building F. 123

Table 4.19. Summary table of case studies. 129

LIST OF ACRONYMS / ABBREVIATIONS

AHU	Air Handling Unit
AP	Accredited Professional
ASHRAE	American Society of Heating, Refrigerating and Air-conditioning Engineers
BRE(EAM)	Building Research Establishment (Environmental Assessment Method)
CASBEE	Comprehensive Assessment System for Built Environment Efficiency
CDP	Carbon Disclosure Project
CE	European Conformity
CEDBIK	Turkish Green Building Association
CFC	Chlorofluorocarbon
CFD	Computational Fluid Dynamics
CHP	Combined Heat and Power
CO_2	Carbon Dioxide
COP	Coefficient of Performance
CP	Control Panel
DCLG	Department for Communities and Local Government
DGNB	German Sustainable Building Council
DOE	United States Department of Energy
EC	European Communities
EF	Exhaust Fan
EFQM	European Foundation for Quality Management
ENR	Engineering News-Record
EPA	Environmental Protection Agency
ESC	Erosion and Sedimentation Control
EU (4)	European Union (filter efficiency rating)
FCU	Fan Coil Unit
FSC	Forest Stewardship Council
FT	Financial Times
GRHCC	Greater Riverside Hispanic Chamber of Commerce
GSA	General Services Administration

HQE	High Quality Environmental Standard
HVAC	Heating, Ventilation and Air-conditioning
ICSI	International Commission for Snow and Ice
IGBC	Indian Green Building Council
IPCC	Intergovernmental Panel on Climate Change
ISO	International Organization for Standardization
KALDER	Turkish Quality Association
KUDEB	Directorate for the Inspection of Conservation Implementations
LED	Light-emitting Diode
LEED-(NC)	Leadership in Energy and Environmental Design – (New Construction)
LEED-EB	Leadership in Energy and Environmental Design for Existing Buildings
MPR	Minimum Program Requirement
N/A	Not Available
OHSAS	Occupational Health and Safety Assessment Specification
PVC	Polyvinyl Chloride
TCA	Turkish Contractors Association
TEMA	Turkish Foundation for Combating Soil Erosion, for Reforestation and the Protection of Natural Habitats
TL	Turkish Lira
TOKI	Housing Development Administration of Turkey
TS(I)	Turkish Standard(s Institution)
TURCEK	Turkish Environmental and Woodlands Protection Society
UAE	United Arab Emirates
UK	United Kingdom
(UN)CED	(United Nations) Conference on Environment and Development
UNEP	United Nations Environment Program
USA	United States of America
USGBC	United States Green Building Council
VOC	Volatile Organic Compound
VRV	Variable Refrigerant Volume
WGBC	World Green Building Council
WWF	World Wildlife Fund

1. INTRODUCTION

1.1. Background of the Research

Sustainability is the concept of social, economic, cultural and structural dimensions and also a projection of structuring the future finding the balance between nature and mankind in order to meet the needs of posterity. Sustainable structures have been a popular research area and a substantial concept that rises in importance more and more because of global warming and increasing energy costs. During both construction and living stages of buildings, increasing quality of life is as important as efficiency in both use of resources and services.

Green building certification systems are examples of methods that were developed in order to support any effort to reduce adverse impacts of buildings on environment and to promote clients and technical staff who work or make an effort in this direction. They become prominent generally for new constructions; however they can also be practiced in renovation works that may be called as *recycling activities*. Certification systems give an opportunity to evaluate existing building stock and convert them to environmental friendly buildings.

1.2. Problem Determination

Environmental challenges like global warming and fresh water supply became more of an issue today hence environmental friendly or sustainable buildings concept becomes ever popular. Research results clearly present that major parts of energy consumption and water use all over the world result from buildings. People also spent a large share of their lifetime in buildings during work, rest and etc. All these reasons bring environmental friendly, sustainable, more efficient and low energy, namely *green buildings,* into the front scene.

Green buildings do not only save energy and water but also contribute to occupant’s health and comfort. According to international studies, employees and inhabitants in

sustainable buildings become ill less often and have more work performance than people in other buildings (Clevenger, 2008). During design works of green building projects, factors directly affecting human health such as temperature and humidity control, indoor air quality, natural lighting and waste management are planned. Thanks to modern construction methods, it is also aimed to leave a cleaner environment to end users in green building projects.

Developed countries have a comprehensive knowledge of green buildings and have been working with this awareness for more than 20 years. However, there has been lack of awareness in developing countries like Turkey for years; hence they must review their legal regulations of green building implementations. Since there is a large building stock in Turkey that has to be protected and kept functional, all restoration, renovation and conversion projects must be carried out considering green building requirements. When existing buildings are converted to green buildings, they will consume energy as much as newly constructed green buildings and also serve people for years. Eighty percent of existing building stock in Turkey consists of old and unsafe structures and in addition to this there is a housing deficit of 2.5 million (Milliyet, 2012). For this reason, it is expected that in the next 20-30 years there will be a large amount of construction work in Turkey with increasing number of urban regeneration projects.

1.3. Problem Statement

There is a small number of building projects constructed as green from scratch when compared to total construction works all around Turkey and number of green building renovation projects is even less than this. Furthermore, when one looks at projects certified under certain international green building rating systems, the number decreases significantly. Since green building is a relatively new concept in Turkey, there are certain questions both in owners' and contractors' minds about implementing innovations, supplying environmental friendly construction materials, and encountering additional costs in a green building project.

Review of literature shows that there are many studies about green new construction projects however there is less information about conversion of existing buildings to green ones. This research is based on investigation of factors influencing green building conversion projects and the ways in which such projects can be completed efficiently and effectively in Turkey.

1.4. Related Studies

Research studies about green building implementation both in America and Europe have been popular over the last few years. There are studies about green buildings' cost and benefits (Kats, 2003; Tatari and Kucukvar, 2011), energy performances (Diamond *et al*., 2006; Fowler *et al*., 2010; Sinou and Kyvelou, 2006; Bell, 2004), investment trends in LEED properties (Fuerst, 2009) and energy efficiency in existing building stock (Waide, 2007; Brook *et al*., 2005; Holness, 2008). Besides, there are also studies about green building projects in Turkey (Ozcan and Temizbas, 2010; Adiloglu, 2010). However, there is not any study in the literature about existing buildings that were converted to green buildings through renovation in Turkey since the number of such projects is very limited and it is a new concept in the country.

1.5. Aim and Objectives of the Research

The major aim of this research is to analyze the greening process of existing buildings and thereby find out barriers that were encountered during green building project design and construction processes in Turkey and how they were overcome by project teams. It was aimed at examining whether green building projects are so expensive, difficult and time consuming to be implemented that several clients and executives are afraid of. This research is expected to help people who intend to invest in green building projects or think of implementing such projects in Turkey successfully. This study may serve as a guide for such people.

In this respect, following are the objectives of this research:

- Gathering general information about green building projects in Turkey that fall into the research topic
- Determination of reasons why owners decided to implement green building projects
- Identification of innovative activities implemented in the projects
- Discussion of difficulties encountered in green building projects and their solutions
- Determination of benefits both at project and organization level
- Identification of lessons learned from project stories
- Recommendations on designing, managing, and constructing successful green building conversion projects in Turkey.

1.6. Research Method

A qualitative case study methodology has been applied in this research to gain a better understanding of project based implementations in existing buildings that were converted to green. The objective has been to find answers of *why* and *how*. Case studies were performed on different green building projects in Turkey. Face to face interviews were made with different people and numerical, written and visual data were taken from the interviewees. The views of different clients, engineers, architects and also contractors were sought. After each case study, lessons were provided based on the challenges or difficulties that project team members experienced and the solutions that they employed in their projects.

1.7. Scope and Limitations

This study has a strict limitation based on choice of research area: only existing buildings that were renovated and converted to green buildings have been investigated in this research, however buildings that were constructed as green buildings from scratch were beyond the scope of this research. Green building is a wide concept including many different principles from different disciplines and for this reason, it was necessary to limit the scope of the research with a specific type of green building which was chosen in this study as renovation and restoration projects.

Another limitation was that only projects certified under a green building certification system were covered in this research. When existing buildings converted to green buildings and certified under international certification systems in Turkey are investigated, it is seen that there are only LEED certified buildings of that type. In spite of this, all structures in Turkey certified under the BREEAM are examples of new constructions. This caused that existing green buildings certified under LEED constituted the sample for research.

1.8. Organization of Thesis

In the second chapter of this thesis, history of green buildings, worldwide known certification systems and green building trends both in the world and Turkey are explained. Importance of conversion of existing building stock to green buildings was mentioned. In the third chapter, research methodology is presented and general information about case studies in this research is given. Case studies with all available information are explained in detail in the fourth chapter. Findings are presented and discussed in the fifth chapter. Besides, common properties and outcomes of examined projects were first determined and then indicated also in this chapter. In the last chapter, conclusions are drawn and lessons learned from the case studies were briefly summarized.

2. LITERATURE REVIEW

2.1. Climate Change and the Remedy: Sustainability

It is explained by academicians that natural balance on earth has been disturbed since the industrial revolution has occurred. Indications of such a disturbance are clearly seen today. Climate change, decrease in number of species and flood disaster are some examples of these signs. Greenhouse gas emission, global warming, environmental pollution, rapid population growth in the world and depletion of natural resources may lead to worse catastrophes. According to a climate change report, glaciers in the Himalaya are receding fast and if the present rate continues, it is expected that the total area of glaciers lands would decrease to 100,000 km^2 by 2035 which covers nearly 500,000 km^2 now (Cruz *et al*., 2007).

Recent research also demonstrates the direct relation between men induced greenhouse gas emissions and the increase in the temperature over all the world, extreme weather and natural disasters that have occurred over the last 50 years. It is stated in McGraw-Hill's study (2008) that these emissions are also linked to increased vapor in the atmosphere, heavier levels of precipitation and the potential cause of the increase in sea temperatures in places where hurricanes form. Some of the future projections of climate change are the following: temperature will keep on rising and heat waves will occur more frequently, evaporation and droughts will increase, precipitation will become more intense but less frequent and instances of hurricanes, typhoons and associated core rainfall rates will increase.

Personal awareness in resource management and evolution of environmental effects is important but what is more important is that construction sector that includes erection and management of buildings must be controlled with local and international standards since its environmental impact is massive. Existing international protocols, national and regional specifications and standards are several examples of curative attempts. At this point, the concept of green building appears with its sustainable principles and gains importance providing a more comfortable and better life quality and limiting sourcing and

environmental impacts of buildings. Green buildings which include examples of environmental friendly implementations are designed in order to solve aforementioned nature issues and build a sustainable future. They are structures that use key resources like water, electricity, gas, materials and land more efficiently than other buildings that are just built in compliance with local codes. It is an understanding of erecting buildings considering their impacts and providing sustainability, vital circulation in the nature and recycling whereas sustainability is capacity to be maintained or to endure.

According to the United Nations' definition, sustainability calls for an appropriate standard of living for every living being without comprising the needs of future generations (UN, 2011). It is stated in the Brundtland Commission's report, *Our Common Future* (UN, 1987), that sustainability has emerged as a widely held concept to guide all future efforts. It requires that people become less wasteful of resources and take appropriate steps in order to provide that natural life remains functional and biologically productive and they regard future of the next generations. Sustainability covers ideas other than environmental performance. It has social and economic dimensions, covers all aspects of human activity. A sustainable building is meaningless without reference to these broader contextual issues (Cole, 2010). In *Agenda 21* that was declared at the 1992 UNCED Summit meeting in Rio de Janeiro, international agreements have expanded technology transfer and development assistance to reach global environmental goals. Then three messages emerged from the regulatory compliance arena (Post and Altman, 1994):

1. Governments must be aggressive in addressing their pollution control needs

2. Local and global cooperative organizations must be developed to address trans-border pollution problems

3. Strategies legitimizing environmental externalities must be discouraged whereas regulation and taxation should be used to discourage ecologically harmful behaviors and promote beneficial alternatives.

Study of McGraw-Hill (2008) presents that buildings are the world's heaviest consumers of natural resources and account for the following environmental impacts: 40% of total global CO2 emissions and 45% of in the EU, 30% of global raw materials consumption and solid waste output. When the global energy sector's consumptions are investigated, it is seen that the energy sector contributes as much as 90% of CO2 and 70% of greenhouse gases according to the UN (Garg *et al*., 2006). Besides, the energy used to erect and operate buildings contributes almost half of industrialized countries' total energy use. The CDP which is a non-for-profit organization made an investigation of how the largest companies of FT Global 500 respond to climate change. The questionnaire that was conducted by the organization team had a response rate of 77% and it was found that 76% of the responding companies implemented a greenhouse gas emissions reduction initiative (CDP, 2006).

According to a market report that analyzed green building activity around the world from the point of view of market adopters and construction sector professionals from 62 different countries including Turkey, green buildings achieve large market adoption at extreme rates in every region of the world. According to the report, green share of building activity in the total sample is 38% (McGraw-Hill, 2013). Some of the research results are: global level of firm involvement over time among companies around the world was 24% in 2009; 49% in 2012 and it is expected to be 71% in 2015. These percentages show the rate of companies which are partially dedicated (>30%) to green building concept. More than half of industry companies foresee rapid sales and profit growth about green building projects within the next five years. Hence corporate sustainability and struggle against global warming are one of the prominent topics that will be discussed in academia and business environments around the world. FT 500 companies calculate their carbon footprint which is the total amount of greenhouse gas emissions that arise from the organizations in order to see their path to carbon neutrality that is achieving zero carbon emissions. They recognized the necessity of greening their buildings. An executive at Jones Lang LaSalle stated: "The path to sustainability often starts with real estate facility strategies." Companies have different breakdowns of their greenhouse gas emissions and aim to achieve a net zero carbon footprint by reducing energy use through efficiency in

their buildings and productions, utilizing renewable energy and purchasing environmental friendly products (Dirksen and McGowan, 2008).

2.2. Evolution of Green Buildings

The first activities and commitments in green building concept happened in the USA. In the 60's and 70's several architects paid more attention to ecological impacts of what they were doing. The USA's first standards for energy efficient governmental office buildings were erected in California. The ASHRAE Standard 90 which was a prescriptive energy design standard was created in 1975. Then it has become a benchmark for energy codes. Between 1978 and 1980, the dialogue about mandatory performance standards grew in response to new research funded by DOE and intensive debates coordinated by the National Institute of Building Sciences. In 80's green building activities in Europe raised the movement to a higher level. The *Passivhaus* concept was proposed by professors Bo Adamson from Sweden and Wolfgang Feist from Germany. This voluntary low energy building design standard was used for more than 6,000 commercial and residential buildings and promoted the development of a range of energy saving building products. Frank Faraday from the European Construction Industry Federation called Passivhaus "*very much the starting point for the sustainable building movement in Europe and the model in vogue in many EU states*". Arup, a British based design firm, worked with owners instead of developers in order to incorporate some sustainable measures in a series of corporate headquarters buildings (McGraw-Hill, 2008).

Green building resources, establishment of industry associations and consortiums characterized the green building movement during 1990's. The American Institute of Architects created their Committee on the Environment in 1990. They tried to bring this resource to the global level at its 1993 convention and held with the International Union of Architects World Congress where more than 3,000 architects signed a *Declaration of Interdependence for a Sustainable Future*. The BREEAM was launched in the UK in 1990 and the USGBC was launched in 1993 which was the first professional network of its kind for all in the green building field. In 1992 the Energy Star program was established that is a US EPA voluntary program which helps businesses and people save money and protect the

climate through superior energy efficiency. The international awareness of climate change and the need for action has grown dramatically since 2000. As a result, the number of collaboration and green building initiatives among intergovernmental and global nongovernmental organizations has increased. In 2005 *the Kyoto Protocol* became effective as the most widespread achievement about greening the world. The protocol was signed by 182 parties, required developed countries to reduce their carbon emissions by 2012 and established monitoring and reporting of emissions among developing countries. Other two global achievements in the 2000's were the formation of the Sustainable Buildings and Construction Initiative partnership between the UN and industry stakeholders in 2006 and the International Initiative for a Sustainable Built Environment in 2001. Figures 2.1. and 2.2. below show the global green building milestones.

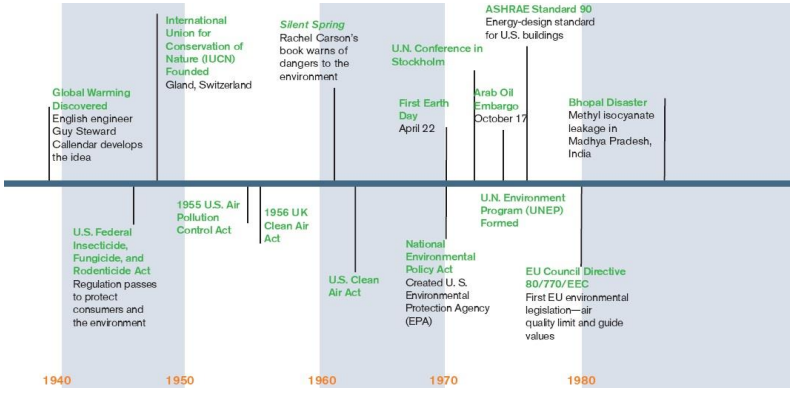

Figure 2.1. Green building milestones between 40's and 80's (McGraw-Hill, 2008).

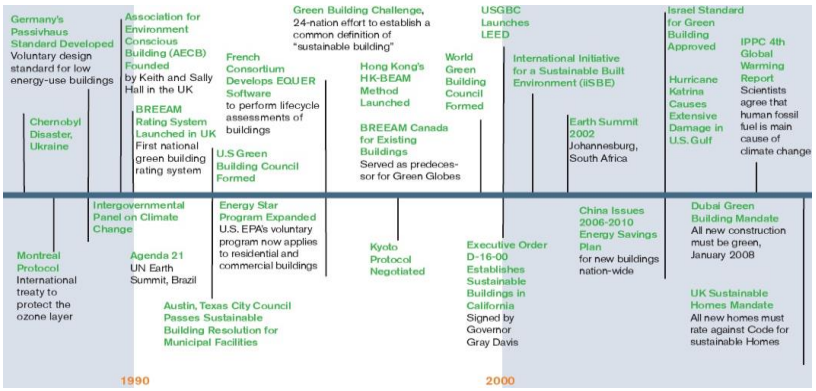

Figure 2.2. Green building milestones after 90's (McGraw-Hill, 2008).

2.3. Benefits of Green Buildings

Green buildings provide financial benefits that conventional buildings cannot. These benefits include reduced waste, improved indoor environmental quality, energy and water savings, reduced employee health costs and lower operation and maintenance costs. According to Kats (2003), green building energy savings primarily arise from reduced energy purchases and secondarily from reduced peak energy demand. On average such buildings are 28% more efficient than conventional ones. The environmental and health costs related to air pollution caused by fossil fuel use are usually not considered when making investment costs however people spend 90% of their time inside the buildings and the concentration of pollutants indoors is typically higher than outdoors, sometimes by as much as 100 times (EPA, 2003). The costs of poor indoor environmental quality are hard to measure and usually hidden in sick days, medical costs and lower productivity. Green buildings help people keep healthy by improving indoor air quality and comfort.

There is a complicated relationship between employee productivity and building design and there are many studies and reports underlining reduced absenteeism and increased perceived productivity over employees in green buildings. Some relevant attributes common in green buildings which improve healthier work environments are the following (Kats, 2003):

- On average 30% more energy efficient
- Lower source emissions from measures like better positioning and better building material source controls
- Better lighting quality including receiving more daylight and use of shading, less glare and more occupancy control over light level
- Improved thermal comfort and better ventilation, CO_2 monitoring to provide better performance of systems like air conditioning and heating

According to a study (Kats, 2006) investigating greening of school buildings, green schools use an average of 33% less energy than conventionally designed school buildings. Typical energy efficiency implementations include efficient lighting, use of daylight and sensors, efficient heating and cooling systems and highly insulated walls and roofs. These schools reduce their emissions. Research results of the same study present that green schools achieve an average water use reduction of 32%. This reduction has direct savings as well as substantial benefits from lower pollution and reduced infrastructure costs to supply water and treat waste water. The typical green school uses one third less energy than conventional ones. This reduction is a result of a combination of better design, energy efficiency equipment and energy efficiency measures such as increased insulation. It is also stated that the impact of improved temperature control in classrooms on productivity is direct and the improvements range from 0.2% up to 15%. Kats (2006) states that good lighting improves test scores, reduces off-task behavior and plays a significant role in the achievement of students.

In McGraw-Hill's research (2013), it is remarked that lower operating costs e.g. energy costs, total lifecycle costs are the major benefit of green buildings. Other benefits can be seen in Figure 2.3. In another survey conducted by Turner Construction (2005) it is found that green schools reduce student absenteeism and improve student performance. Kats' study (2006) finds a certain relationship between improved indoor air quality and human health. The health impacts such as flu, asthma, sick building syndrome, headaches and respiratory problems are improved ranging from 13.5% up to 87% through green building implementations. Research indicates also that teachers emphasize that their ability to control classroom temperature is an important tool for student performance. It is mentioned that workers with good views in the office perform better than others so increasing daylight in green buildings is very crucial. Green buildings usually use more renewable energy both on site and off site than conventional buildings. Use of renewable energy displaces less labor intensive and more polluting energy sources such as heating oil, gas and coal burned in power plants to generate electricity. It is sometimes a reason for governments why they prefer building green structures that there is a positive employment impact of them. For instance, only 2.5 jobs are created for every 1,000 tons of waste disposed whereas 4.7 jobs are offered for the same amount of waste diverted (Kats, 2006).

Another benefit of green buildings is heat island reduction measures. Non-reflective building surfaces absorb more sunlight so temperature within buildings increases. This effect creates urban heat islands and associated need for increased air conditioning. Dark roofs can be substituted with green or reflective roofs so local temperature falls as heat is reflected back into space rather than absorbed locally. By reducing ambient urban temperatures smog formation is cut, comfort and health are improved and costs of air conditioning are decreased. Papadopulos and Giama's study (2009) summarizes the main benefits of sustainable construction as the following:

Environmental benefits:

- Protection and enhancement of ecosystems and biodiversity
- Reduction of solid waste
- Improvement of air and water quality
- Environmental optimization of buildings over their life span from design to demolition
- Conservation of natural resources

Economic benefits:

- Reduction of operational and maintenance costs
- Optimization of the life cycle economic performance
- Improvement of labor productivity and inhabitants' satisfaction
- Enhancement of asset value and profits

Health and community benefits:

- Contribution to the overall life quality
- Improvement of air, thermal and acoustic environment
- Enhancement of health and comfort
- Minimization of strain on local infrastructure

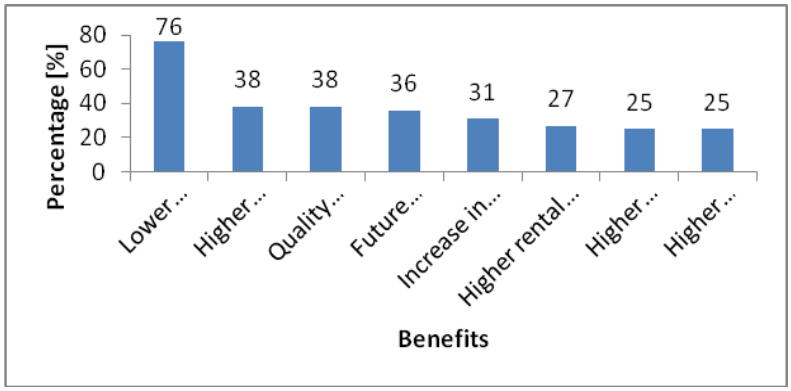

Figure 2.3. Benefits of green buildings.

2.4. Motivation for Green Design

The concept of life cycle assessment has been generally accepted within the environmental research community as the only legitimate basis on that building environmental assessment methods are formulated (Cole, 2010). It is a technique to assess the environmental aspects and potential impacts associated with a product, process or service by compiling an inventory of relevant energy and material inputs and environmental releases, evaluating the potential environmental impacts related to identified inputs and interpreting the results to help decision makers make a more informed decision (EPA, 2006). However, life cycle analysis of buildings is more complex than that of other products. Cole (2010) states that the full life cycle environmental impacts of building materials and components can be broken down into different phases:

- The detailed assessment of the acquisition and production impacts and resource use
- Impacts and resource use throughout the useful life of the completed building
- Demolition and disposal impacts

There are also certain motivations and reasons why clients want to work or live in green buildings. For instance, householders seek to decrease their utility bills, employers try to increase the productivity during work hours in office buildings, governments implement green building tools as pioneers in order to encourage people who hesitate to have green structures and companies prefer to have green commercial buildings in order to gain a reputation and follow the market trends. According to the green building market report of McGraw-Hill (2008) which used data from 45 different countries, green buildings offer the opportunities mentioned in Table 2.1. to decrease the negative impact on environment caused by buildings. However, a major change has occurred since that market report when *doing the right thing* was the primary motivation to green building. By 2012, client demand and market demand have become the dominant forces in the market, despite the fact that the rate that consider them important drivers has remained relatively consistent from 2008 (McGraw-Hill, 2013). The most important global business, social and environmental motivations for green buildings on that practitioners agree can be seen in Figures 2.3., 2.4. and 2.5. respectively.

Table 2.1. Reduction caused by green buildings on environmental impacts (McGraw-Hill, 2008).

Impact	**Reduction [%]**
Energy Use	30-50
CO_2 Emissions	35
Waste Output	70
Water Usage	40

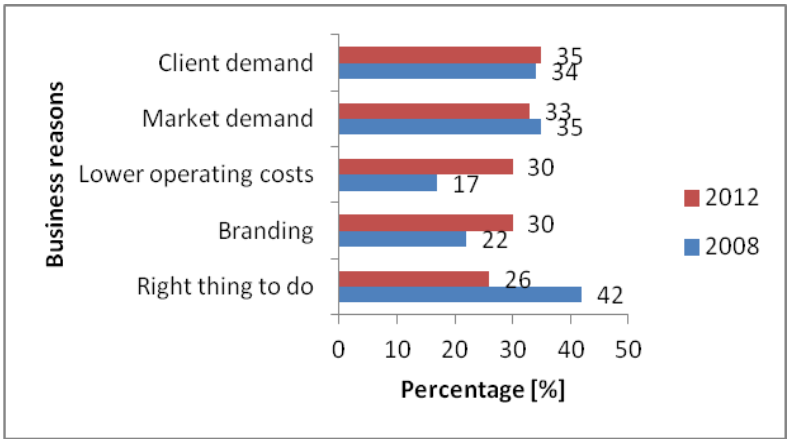

Figure 2.4. Top global business reasons for green buildings.

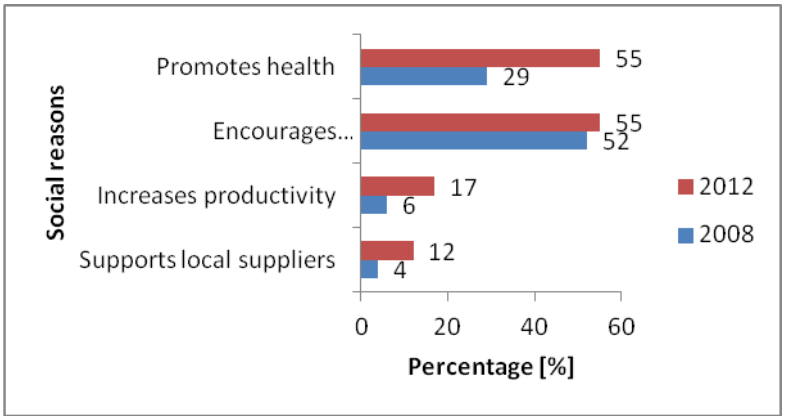

Figure 2.5. Top global social reasons for green buildings.

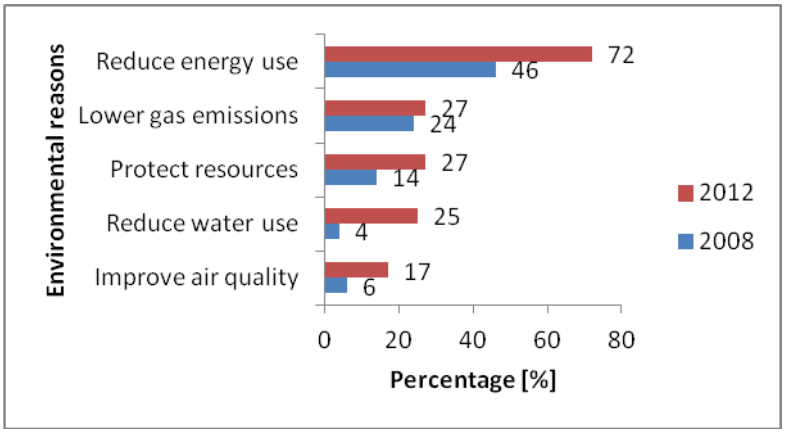

Figure 2.6. Top global environmental reasons for green buildings.

Besides, the internet is used by the largest percentage of the construction industry to get information on green trends. However, conferences and industry associations also serve as a key resource for more than half of the firms around the world (McGraw-Hill, 2013). Figure 2.7. shows information resources relied on and trusted for green building information.

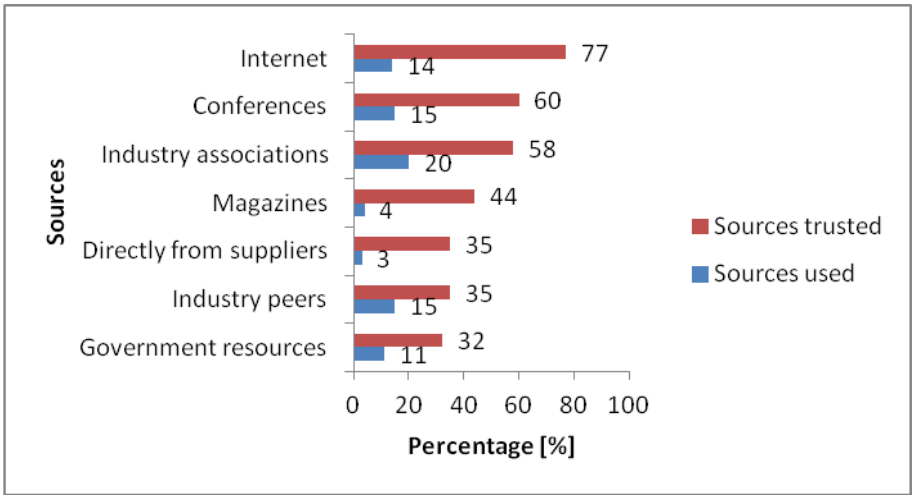

Figure 2.7. Information sources to get information on green trends.

2.5. Cost of Greening

The *green premium* is the initial extra cost to implement green building tools compared to a conventional building (Kats, 2006). It is often cited as a major barrier towards adoption of green development. Typically, this premium is a result of sustainably sourced more expensive materials, more efficient mechanical systems and better design, modeling and other performance measures. Increased cost of green design is partially offset by savings elsewhere, for instance in reduced costs of HVAC systems or in reduced legal compliance costs. In addition to this, increased water retention through green roof, grey water treatment system or sensor faucets can avoid the capital cost of a water retention system normally required to comply with the codes.

Several studies have been performed considering the cost premium of green buildings. Davis Longdon's study (2007) analyzed Australian Green Star rating system by

comparing the cost of the green and conventional buildings to estimate the cost premium of the green building rating system on construction costs. He concluded that a 5-star green building had a 3-5% premium with respect to a non-green counterpart. Rawlinson (2007) concluded in another study that the cost premium of green buildings certified under BREEAM was 6% that is explained by sustainable design features for the building. Fowler and Rauch (2008) revealed that the cost premiums of LEED certified buildings range from 1% to 8% with respect to the level of LEED certification desired. Kats' survey (2006) conducted on 30 green school projects that were built in ten different states in America between 2001 and 2006 reveals that green design caused 1-2% additional cost when compared with a conventional design. An in-depth analysis of LEED-NC certified structures (Kats, 2003) reveals that high performance sustainable building projects require higher capital investments and the capital is proportional to the intended building overall LEED rating. According to that analysis, the cost premium of the green project is likely to follow the increasing cost trend with respect to the higher levels of LEED system. Nilson (2005) estimated cost premium for LEED Gold certification to be 0.82% of total construction costs for a New York office building. Another study (Stegall, 2004) revealed that estimated cost premium for a new house that aims to achieve LEED Silver certificate would be 1-2.8% of the total project cost. It is estimated in Packard Foundation's study (2002) that 0.9%, 1.3%, 1.5% and 2.1% of total hard costs are required to achieve LEED Certified, Silver, Gold and Platinum relatively for an office building. As it can be seen from above mentioned examples, there is a cost premium for constructing green structures although there are different studies revealing different rates for different types of buildings. However, it is also seen that the premium is not more than 10% of total construction cost of a building and usually ranges between 1% and 5%.

Green building maintenance costs are less than conventionally built ones over their life time. This can be seen when life cycle analysis is performed. However, the cost premium is often cited as a major barrier towards adoption of green implementations. A common practice to determine the costs between a conventional building and a green project is to aggregate the costs of all comparable features. When this methodology is used, it is seen that green buildings are usually the more expensive option. In fact, such comparisons are misleading since they do not consider that the green projects need to

follow a more integrated design and construction process than what is typically required by conventional projects (Choi, 2009). Besides, the most important benefits associated with green developments including external impacts on the community are not realized until post construction stage. Considering these additional benefits and using full cost accounting procedures provide more fair assessment as building expenses are never limited to just investment and service costs. When calculating cost of green development, it must be taken into consideration that the benefits are most evident over the longer term where a better designed and erected structure can save the owner and tenants on operating and maintenance costs. Kats (2003) states in his green building costs and financial benefits study that total financial benefits of green structures are over ten times the average initial investment required to design and construct a green building. Since an investment of any building has ongoing cost components, a more reasonable comparison of value would include the maintenance and operating costs of the building. While lower maintenance and operation costs are one of the key selling points of green structures, there are also other benefits such as higher occupancy, rental rates and sales prices that should be added to overall cost.

2.6. Common Green Building Implementations

There are many different measures, implementations and practices used in green building projects in order to save water and energy consumptions, reduce environmental impacts of structures and increase efficiency in mechanical and electrical systems. Types of practices depend on different characteristics of the regions where measures are taken. For instance, renewable resources are prominent in Europe, water efficiency is common in Sub-Saharan Africa and Europe has the highest current use of solar power and geothermal power (McGraw-Hill, 2008). Some of the measures taken and implementations practiced in different parts of the world are the following: *heat pumps* use thermal water underground and transfer the heat energy to households. *Winter gardens* in houses are constructed in order to make use of daylight and temperature by covering with glass panels. *Green roofs* are covered with vegetation and plants so that they provide insulation, absorb rainwater, lower urban air temperatures by mitigating heat island effect and also creates habitat for wildlife. They reduce the amount of heat penetration through roofs and

the roof temperature by absorbing heat into their thermal mass and due to evaporation of moisture. *Natural ventilation* within buildings is an important architectural tool that must be considered during design phase of the structures. They provide circulation of the air without implementing any mechanical practices and save energy from cooling consumptions of the building. *Solar thermal collectors* are designed to collect heat energy by absorbing sunlight. They are especially used in sun drenched regions in order to heat water. *Photovoltaic panels* convert sunlight to electric energy. *Urban wind turbines* convert wind energy to electric energy in cities. *Use of recycled materials* and *planting of local and less water demanding vegetation* are also other examples of common environmental friendly implementations in green building projects.

According to McGraw-Hill's research (2008), top green building practices in the USA are used in energy and atmosphere measures in order to increase energy efficiency. Details are presented in Figure 2.8. According to the same study, solar power, geothermal power and wind power are the top three forms of alternative energy used in America. The same company's another study also shows that mechanical and electrical are the most frequently used products installed. Thermal and moisture protection products are also expected to enlarge their share (McGraw-Hill, 2013). Figure 2.9. shows categories of green building products used in 2012.

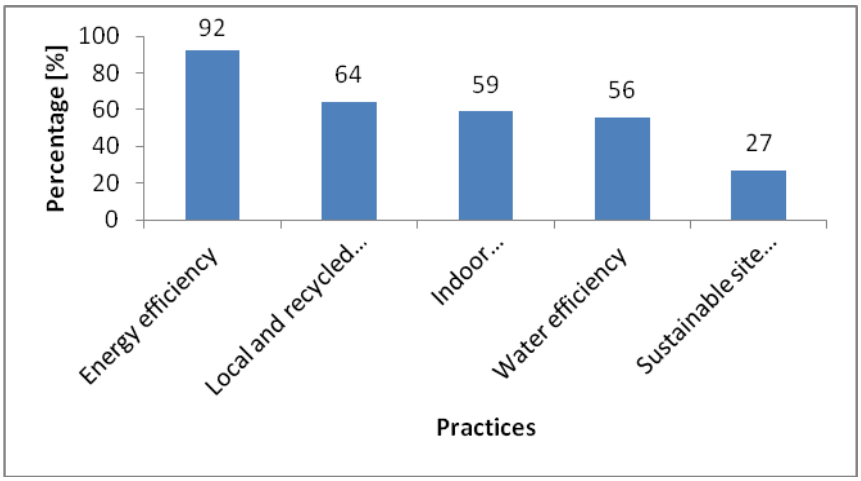

Figure 2.8. Top green building implementations in the USA.

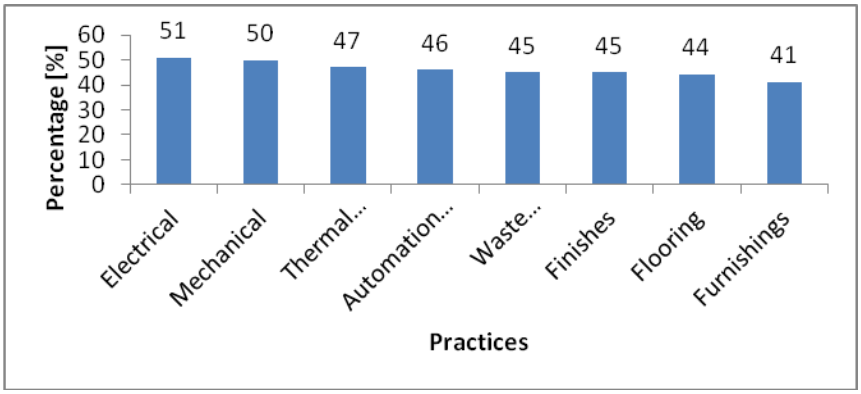

Figure 2.9. Installation and specifications of green products.

Various green elements, technologies and systems in green building industry are summarized into a comprehensive list in a study (Zhang *et al*., 2011). The list can be seen in Table 2.2. with its key references.

Table 2.2. Common green elements in building development (Zhang *et al*., 2011).

Green Elements	**Key References**
Considering environmental impact when selecting project site	UNEP (2005)
Design for better microclimate and environmentally responsible housing	UNEP (2005)
Optimizing building orientation and configuration for better energy performance in design stage	Glicksman *et al*. (2001)
Application of underground space development technology to save land resources	Parker (2004)
Green landscape design and use of wetland landscape technology	Pei *et al*. (2009)
Application of green roof technology	GRHCC (2003)
Application of solar system technology	Ecotecture (2006)
Application of efficient equipment and appliances for natural ventilation	DOE (2009)
Use of environmental friendly materials for HVAC systems	UNEP (2003)
Optimizing building envelope thermal performance	DOE (2009)

Table 2.2. Common green elements in building development (Zhang *et al*., 2011) (continued).

Integrative use of natural lighting with electric lighting system	Hong Kong Green Building Technology Net (2009)
Ample ventilation for pollutant and thermal control	DOE (2009)
Application of waste management technology	Vanegas *et al*. (1995)
Application of minimizing the disruption to living environment technology	UNEP (2003)
Application of Low E insulation window technology	Kirbyand Williams (1991)
Application of decentralize drain water technology	Partzsch (2009)
Application of ground source heat pump technology	Doherty *et al*. (2004)
Application of innovative waste water technology	Chen *et al*. (2005)
Application of prefabricated concrete technology	Tam (2009), Noguchi (2003)
Application of green technology monitor and maintenance system	DOE (2009)
System for green facility management	Nousiainen and Junnila (2008)

2.7. Performance of Green Buildings

Diamond (2011) conducted a research about the energy performance of the first generation of LEED certified commercial buildings. He aimed to provide a quantitative assessment of green buildings' actual and simulated energy performance. There are some reasons why buildings do not perform as modeled. Changes in design and construction or operation and maintenance issues that can change the energy consumption of the building are examples. Several LEED-NC buildings in America were investigated in Diamond's research and there were difficulties such as comparing modeled and actual consumptions. Buildings as actually built may differ dramatically from the modeled one at the design stage. Different occupancy patterns and densities, type of equipment may make these comparisons difficult to interpret. Diamond states that some LEED buildings were within

10% of their design values despite potential reasons for differences. According to the results that he pointed out that the mean simulated energy savings for 17 investigated LEED certified buildings was 27%. For 18 of the buildings, the actual consumption was lower than simulated by 1% and the number of LEED energy efficiency points did not correlate with actual energy savings.

Another research on the assessment of green building performance in the USA was introduced by another study (Fowler *et al.*, 2010). In that study, performance metrics collected, normalized and analyzed for the buildings include water, energy, maintenance and operations, waste generation and recycling, occupant satisfaction and occupant commute. These performance metrics were chosen to evaluate the purpose of sustainable design or reduced environmental impact while keeping operational costs low and occupant satisfaction high. According to the results, the study buildings on average have an aggregate operational cost 19% lower than the baseline. These costs are water and energy utilities, general and grounds maintenances, waste and recycling and janitorial costs. Two thirds of the buildings investigated in the study use less water than the baseline with average water use 11% below. The energy performance is 25% better. Besides, the average general building satisfaction levels are 27% higher than the baseline. Based on the occupant response to the survey questions, emissions from transport modes result in 29% lower carbon dioxide emissions when compared to average commute. This can be the result of building location, community culture, sustainable design related decisions such as preferred parking for carpools, alternative vehicles and bikes, or locating a building near mass transit options.

2.8. Government Regulations in the World

There are significant policy and regulatory shifts toward greener government buildings in the USA. The Energy Independence and Security Act of 2007 mandates that all governmental buildings reduce energy use 30% by 2015 compared to their 2005 levels. Even some states in America have executive orders requiring that state facilities or state funded projects meet some level of LEED. However, only one state, Boston, applies green standard rules to private construction (Dirksen and McGowan, 2008). Some governments

in the USA offer quicker permitting time for projects that are LEED registered whereas some municipalities require that projects attain LEED certification in order to obtain a building permit. Governments and municipalities play an important role in pushing for green buildings beyond the properties they control.

In the UK, the Royal Commission on Environmental Pollution concluded that the UK should try to reduce its carbon dioxide emissions by 60% from current levels by 2050 and by almost 80% by 2100 in order to stabilize atmospheric carbon concentration at level of 550 parts per million by volume (Bell, 2004). This recommendation was accepted by the government in its Energy White Paper which presents the government's energy and environmental policy.

When different regions of the world are considered then some precautions are seen. For example, in Dubai, all new construction must be green according to *Dubai Green Building Mandate* became effective in January 2008. *Israel Standard for Green Building* was approved first in November 2005. China issued in its *11th Five Year Plan* that covers the period 2006-2010 that 20% reduction in energy intensity by 2010 was a national goal.

Limited CO_2 emissions associated with construction and operation of buildings in Europe account for between 40% and 50% of total emissions. Building industry has become one of the key areas for emission reductions. This was reflected in the requirements of the European Parliament Directive on the Energy Performance of Buildings (EC, 2003) that recommended significant developments in building regulation as they impact on new and existing buildings. According to Bell (2004), the development of a regulation structured to capture as many as opportunities for efficiency improvements as possible needs to be able to:

- Adopt an approach so that efficiency improvements could be treated as a whole

- Take account of the context in that works take place

- Demonstrate a reasonable level of cost effectiveness within the context of scheme of works as a whole

- Provide a range of works as comprehensive as possible to be included in the regulatory definition of building works, especially renewal and major renovation works to building sub system so that every opportunity is taken to make reasonable improvements

2.9. Existing Buildings Stock and Green Building Retrofit

Approximately 86% of building construction expenditures in the USA relate to renovation of existing buildings, not to new construction. New construction represents about 2% of US commercial building stock (Holness, 2008). It is expected in developed countries that more than half of the building stock must be renewed. This shows the importance of renovation works all around the world. In this regard, it must be also mentioned that the building stock in the UK and Europe has a long life and replacement rates are low. The housing stocks for the UK, Denmark, Germany and Netherlands make together 41% of the pre 2004 EU total (Bell, 2004). In Figure 2.10. data on change in the housing stock for these countries is presented. It is seen that construction activity results in stock growth rather than replacement due to replacement rates of less than 0.1% and new building rates of over 1%. Although improving the energy performance standards of new buildings is important, it would require a dramatic change in replacement rates in order to make a significant contribution to reduction of emissions in the next years.

It is clear that overwhelming majority of buildings in the world were designed for the climatic conditions prevalent in their location as they were built. However, these conditions have changed due to climate change and they have been reflected in long term observational records. In many countries, the warmest years on record have occurred in the last decades. There has been a general trend of decreasing rainfall in summer and increasing rainfall in winter with heavier precipitation events. Projection of climate change over the next years shows that buildings will be adversely affected by overheating and flooding as well as by water stress (Arup, 2008).

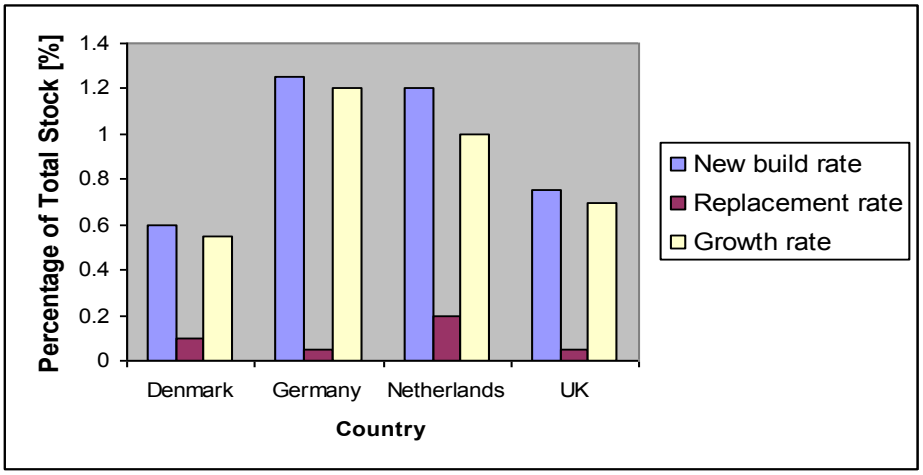

Figure 2.10. Housing stock change characteristics (Bell, 2004).

There are cost effective measures that can be undertaken without a major renovation. For example, proper air tightness is the key to minimizing heat loss due to ventilation for domestic buildings (Roberts, 2008). The performance of most first generation double glazing is poor. Draught proofing also results in fairly small savings but is very cost effective. Some buildings have cavity walls and their thermal performance is normally improved by filling the cavity with insulation that can reduce the heat loss through the walls by up to considerably high rates. More extensive measures include upgrading windows, external and internal insulation and insulation applied to ground floors. Older buildings usually have no insulation at all. Upgrading such buildings would reduce wall and roof heat loss. There is a direct relationship between air quality and air humidity. It is attempted in early insulated houses to control energy losses due to ventilation by reducing ventilation. However, humidity levels below 40% and above 60% offer good conditions for breeding microorganisms (Richarz *et al*., 2007). An insufficient exchange of air usually leads to an increase in the interior humidity. This is the general case in older buildings when draughty windows are replaced by new types while the ventilation habits of users remain unaltered (Roberts, 2008). Some of commercial buildings have poor fabric, inefficient plant, poor controls and low levels of occupant energy awareness. Overheating is common and leading to increased cooling demand. Improving insulation is an important issue which is more crucial than solar control for poorly insulated existing office buildings (Arup, 2008). Insulation measures like installing

loft and wall insulation and double glazing have positive effect on keeping buildings cool in summer and increasing heating efficiency in winter. Besides, insulation also reduces heat loss through building fabric at night. The efficiencies of gas and oil fired boilers have improved rapidly over the last decades through advancing technology like any other heating tools. The time when the building envelope is upgraded is a good time to replace the heating system or changing with a more efficient heating system. Renewable or regenerative sources offer alternative methods for hot water production such as solar, heat pumps or waste heat from industry. The EU also requires consideration of community heating, combined heat and power and renewables as an alternative for all buildings over 1,000 m^2.

Improving efficiency in existing buildings involves a combination of insulation improvement and using efficient heat systems. In a report of sustainability of existing buildings, the UK's DCLG (2006) listed technical measures of improving existing stock. The list includes hot water cylinder insulation, cavity wall insulation, loft insulation, improved heating controls, draught proofing, micro combined heat and power, solid wall insulation, A-rated boiler, ground source heat pump, photovoltaic electricity, solar water heating and windows with double glazing. According to the list, not all measures can be applied across the whole stock since each building has different properties. For example, there may be physical difficulties in dense urban areas installing ground source heat pumps, the lack of an appropriate roof may reduce the effectiveness of solar heating or photovoltaic panels. Micro-CHP can be applied across the majority of the stock where the house is on mains gas.

In a green building retrofit and renovation report (McGraw-Hill, 2009) it is stated that the most appropriate opportunity for green design and construction activity lies not in constructing new buildings but in engaging in the retrofit and renovation of the existing building stock. A true green retrofit addresses more than energy performance and leads to a multitude of benefits: lower energy use, reduced greenhouse gas emissions, water savings and better indoor environmental quality. Several recommendations are made in that study. It is stated that there is a big opportunity in the existing building market for green building products processes and services. According to the study results, financial benefits are the

primary driver for encouraging owners and tenants to perform green retrofits. Improvements for energy efficiency offer the broadest opportunity in the market and energy efficiency will continue to be a requirement for green renovation activity. However, it is also stated that there is a lack of sufficient measurements of the benefits achieved in green retrofits reported by owners and tenants. Another result of the report is that owners and tenants who have completed green retrofit and renovation projects are likely to repeat that activity. All owners who implemented green building retrofit projects in their buildings used more efficient lighting or natural daylight. The other major categories of activities can be seen in Figure 2.11.

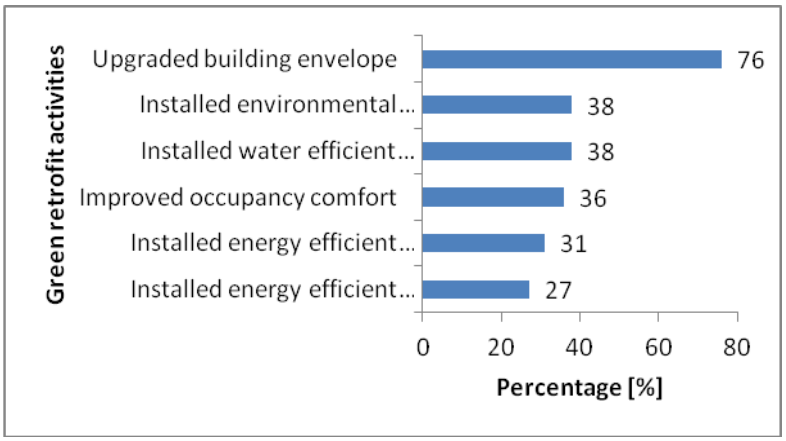

Figure 2.11. Green retrofit activities.

According to the results of the report (McGraw-Hill, 2009), owners seek operational cost savings, increased building values and faster returns on investment. They approach green retrofit and renovation activity by greening their building portfolios more than a single building approach. Research has shown that firms in the USA green their buildings from a broader portfolio point of view and so their savings multiply dramatically. Simple changes in operations and upgrades in maintenance procedures can maximize energy and water efficiency. While commitment to improving buildings through green retrofit and renovation projects is important, new policies such as green cleaning and environmental procurement programs can lead to healthier. It also allows firms which cannot afford renovation activity across their portfolios to gain benefits that will ultimately help improve the environment. Doug Gatlin from USGBC says: "*By improving*

performance of existing buildings, owners and operators will experience substantial cost savings stemming from a number of sources, including reduced maintenance/repair expenditures, resource consumption through improve efficiency and increased occupant productivity due to high indoor environmental quality." (McGraw-Hill, 2009).

According to both tenants and owners, lowering operation costs is the prime motivation for engaging in a green retrofit project (McGraw-Hill, 2009). Other motivations can be seen in Figure 2.12. This result is consistent with other studies performed by McGraw-Hill Construction on the green building market in America. The most important environmental motives are the same for both tenants and building owners. The motives can be seen in Figure 2.13. High energy costs and desire for high performing buildings are the top two triggers for green retrofit and renovation activity by building owners which can be seen in Figure 2.14.

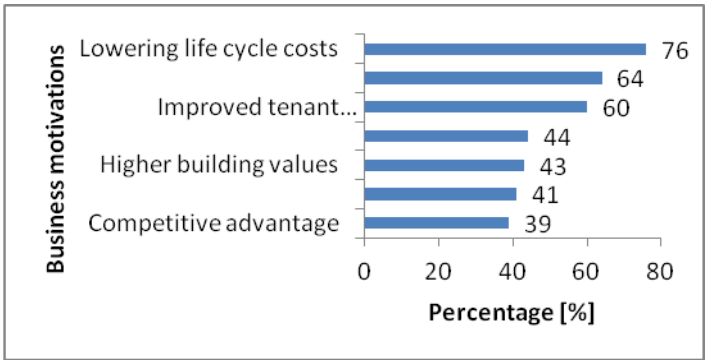

Figure 2.12. Owners' green retrofit business motivation.

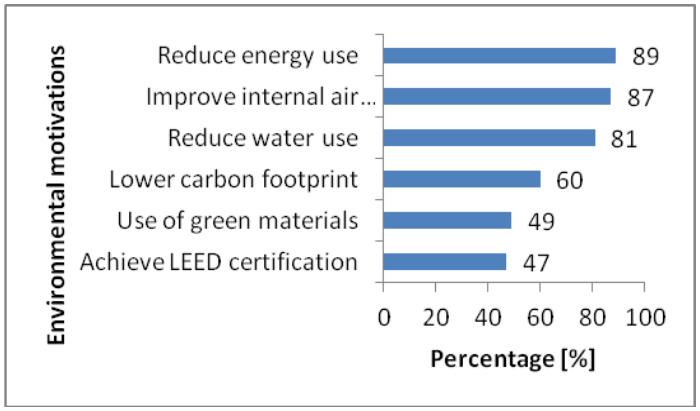

Figure 2.13. Environmental motivations for green retrofit projects.

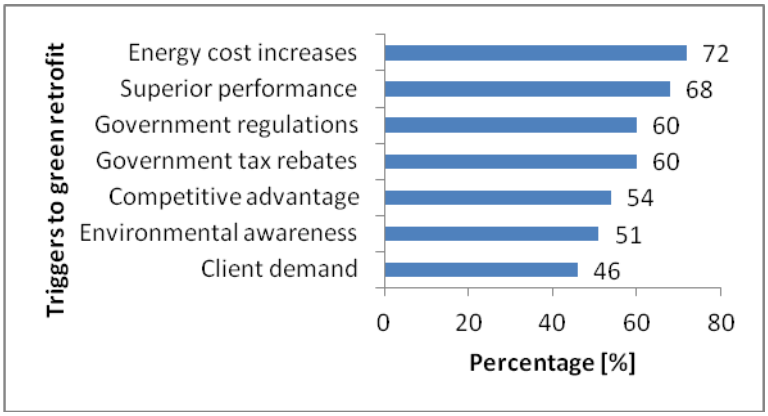

Figure 2.14. Most important triggers to green retrofit.

After years of steady growth in the USA, green retrofitting gains now visibility in construction markets of different countries. In recent years, construction in rapidly growing emerging markets like the UAE, India and China is focused on large scale projects breaking boundaries in scale, design and height. Countries face increasing global pressure to reduce their carbon emissions so they try to find ways of savings in natural and financial resources by investigating existing building stock.

In an interview published in McGraw-Hill's report (2009), Adrian Smith and Gordon Gill who are founding partners of Smith + Gill Architecture explain their opinions about green retrofitting: the main benefit presented by green retrofitting is avoiding the obsolescence of older commercial buildings. Green retrofitting of historic or older buildings positions them to be more competitive and attractive. There is also the potential to save large amount of energy since such old buildings perform inefficiently. According to Gill and Smith, green retrofitting is economically applicable and usually minor in terms of the level of intervention in the buildings. Most clients think that it is easier to integrate green strategies into the design of a new building then retrofitting. A lot of existing buildings can be counted as deficits in terms of energy consumption and carbon emissions but this can be reversed in terms of a financial portfolio especially for people who have large number of existing buildings. It can become a more valuable asset. Gill and Smith also mentions that green retrofitting will keep on growing globally.

2.10. Barriers to Adoption of Green Buildings

Post and Altman (1994) state that an extensive review of published and unpublished case studies of firms has led them to conclude that there are two basic barriers to environmental change: *industry barriers* that reflect the special properties of the business activity in which the companies engage and include technical information, capital costs, competitive pressures, configuration of current operations and industry regulations and *organizational barriers* that are not unique to environmental problems but which affect the firm's capacity to deal with any form of change, including environmental change and include factors like poor communications, past practice, employee attitudes and inadequate top management leadership.

In a study on green strategy for gaining competitive advantage, the major barriers affecting the green building implementations in housing development process have been identified (Zhang *et al*., 2010). Summary of these barriers for applying green elements are listed in Table 2.3.

Table 2.3. Typical barriers for applying green elements in housing projects (Zhang *et al*., 2010).

Barriers	Key references
Higher costs for green design and energy saving material	Williams and Dair (2007), Tagaza and Wilson (2004)
Insufficient policy implementation efforts	Osmani and Reilly (2009)
Technical difficulty during the construction process	Tagaza and Wilson (2004)
Risks involved because of different site practices and contacts	Tagaza and Wilson (2004)
Lengthy planning and approval process for green technologies	Tagaza and Wilson (2004)
Lack of knowledge and awareness to green technologies	The Energy and Resources Institute (2006)
Lack of efficiency for implementation of green building byelaws	The Energy and Resources Institute (2006)
Higher cost in relation to customers demand	Osmani and Reilly (2009)
Unfamiliarity with green technologies resulting in delays in process	Eisenberg *et al*. (2002), Tagaza and Wilson (2004)
Interests conflicts between stakeholders	Williams and Dair (2007)

Choi (2009) mentions in his article that he found that the major reasons for most challenges fell into one of the following major categories:

- Funding issues: industrial and governmental standards used in project evaluation can determine whether projects are financially feasible. Many of these assumptions must be revisited to provide that they do not unintentionally prevent green development by lengthening the payback period.

- Risks and process issues: the lack of expertise and resources for green building often creates an environment that lengthens development time frames. Building codes that were written according to conventional constructions usually do not allow more environmentally friendly systems. Delays may lead to greater risks and higher costs that entrepreneurs would rather avoid given tight budgets and time frames.

- Communication shortfall: there are misconceptions and uncertainty about green buildings and failures in the communication chain regarding the benefits associated with green projects. Lack of demand from consumers exists for such properties. Consumers prefer to pay higher value on amenities such as large space or finishes over less visible properties such as energy efficiency.

- Knowledge gaps in green development qualification: the need for reliable performance, cost and benefit information of green features is important to owners or tenants. Without this information, it is difficult for the market to justify the occasionally higher up-front costs for a green building project.

- Ownership structure and operating cost responsibility: there is little motivation for a developer to build or install energy efficient, transit friendly or on site storm water management tools some of which will only have benefits over the long run if they will sell the building immediately after the completion. Under short term leases where the tenant is responsible for utilities, owners may not want to encounter costs of energy efficient system retrofits.

According to the report of global green building trends (McGraw-Hill, 2013), the biggest obstacle is higher perceived and actual first costs. Green building professionals encounter a range of obstacles to continued market growth with special focus on costs, accounting and the need for education. The green building industry should collaborate to find solutions to these major areas. As the green market grows, increases in demand for sustainable products and knowledge may help professionals lower the costs of these goods. Further awareness also helps educate clients and practitioners about life cycle benefits of green building methods. This knowledge helps defeat the perception that green is expensive.

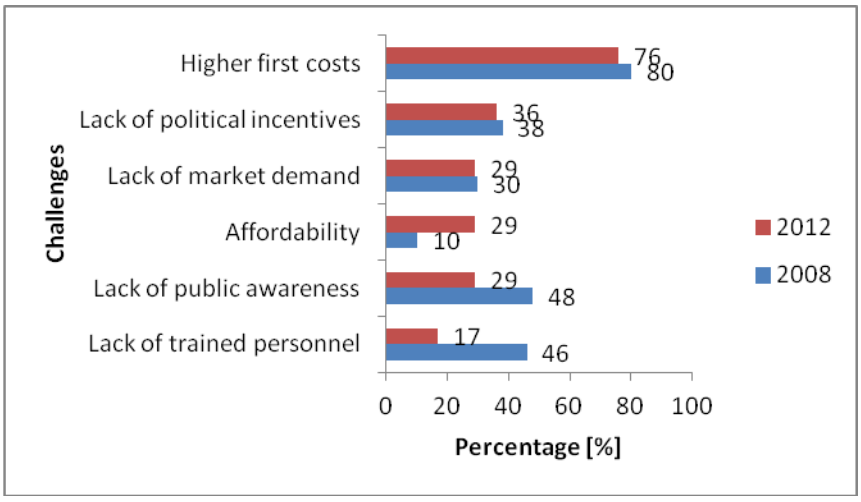

Figure 2.15. Challenges to increasing green building activity.

In the report (McGraw-Hill, 2008), there is an interview with K. B. Albert Chan who is the director of planning and development at Shui on Land from Hong Kong. He states that in China there are very few consultants to help green building professionals. He adds that quality is difficult to find and cost is a basic challenge which has to be overcome. Parasu Roman, the founder of the Indian Green Building Council, explains in the same report that the challenges in green building projects are on the supply side. He states: "*There is a wealth of support for green building but we need more practitioners in terms of contractors, consultants and architects.*" Maria Atkinson, global head of sustainability at Lend Lease, says in the report that the building cycle is the biggest challenge in construction of green structures. To design a building, constructing it and then testing it

after it has been occupied for a year is at least a three year or even a five year cycle. So there is a slow pace of learning and construction sector traditionally learns by applying. According to her opinion, learning is slow and takes time.

When looked at green retrofitting projects, for both owners and tenants, financial concerns are the biggest challenge to engaging in green retrofit projects, according to the report of McGraw-Hill Construction (2009). The results of the report are to be seen in Figure 2.16.

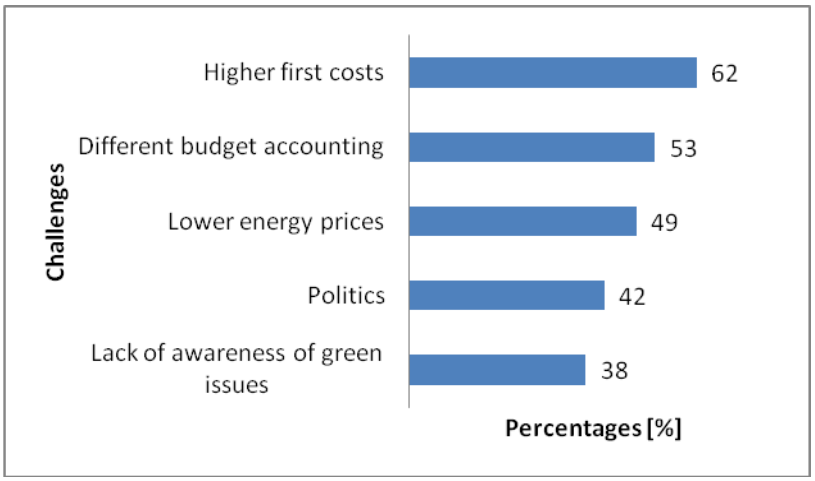

Figure 2.16. Challenges to green retrofitting (owners).

2.11. Development of Green Building Concept in Turkey

In Turkey, 36% of total energy consumption including electricity, gas and solid fuel contribute to residential and service buildings (Republic of Turkey Ministry of Energy and Natural Resources, 2008). For this reason, universities, institutions, associations and governmental agencies perform different works on reducing buildings' carbon emissions and their negative impact on environment.

The first attempt to increase efficiency in buildings in Turkey can be counted as preparing the standard of thermal insulation requirements for buildings in the year 1998, the so called TS 825. Then in the year 2000, heat insulation code for buildings was

published and the regulation of energy performance in buildings in Turkey was enforced in 2011. It is seen that environmental awareness in Turkey has been increasing by time. *The Turkish Green Building Association* (CEDBIK) was established in 2007 and on 4th July 2011 Ministry of Environment and Urban Planning was founded. In February 2012 *the First International Summit of Green Buildings in Istanbul* was organized. Some ministers of Turkish Republic also attended this meeting. During the summit, WGBC President told about their cooperation with CEDBIK and also other presidents of green building councils from all over the world explained their experiences and methods they implemented in their countries. Information about approach of regional green building councils, environmental friendly policies, green economics, conversion of existing structures into green, life in green buildings, cities of the future, environmental friendly construction materials and their production was also shared. How to achieve a net zero carbon footprint was discussed. One of the most prestigious universities of Turkey declared that all of its campuses will have reached carbon neutrality by the year 2023. Efforts and methods for this cause were shared by academicians and administrators of the university. It was stated by CEDBIK that they were working on a national green building certification system and cooperated with the Ministry of Environment and Urban Planning about regulation for energy performance in buildings.

The regulation of energy performance in buildings in Turkey became effective in 2011. According to this law, as from 1st January 2011 all buildings with more than 50 m^2 construction area must have an energy identity card and there must be a central heating system in buildings with more than 10,000 m^2 construction area. Due to such precautions required by the regulation, a large increase in number of green buildings can be expected. TS 825 which is the Turkish Standard for thermal insulation requirements for buildings aims at saving energy by limiting consumption rates of buildings. It also presents calculation methods that must be used in determining energy requirements and aims to provide that energy efficient and highly comfortable buildings are erected. Heat insulation code for buildings aims to prevent possible heat losses and to save energy.

First version of a Turkish green building rating system for residences has been prepared by CEDBIK and was published in June 2013. In preparing this certification

system, LEED, BREEAM and DGNB were taken as examples. There are eight main criteria according to that buildings are evaluated. They are: integrated green project management, land use, water usage, energy use, health and comfort, use of resources and materials, life in residence and operation and maintenance (CEDBIK, 2013).

Ozcan and Temizbas (2010) state that supplier firms that specified their quality standards in compliance with international norms suffer from products of poor quality which find a large share in the market. This fact debases the reputation of Turkish construction sector in the international market and weakens its competitive advantage. It is an advantage that continuous progress is one of Turkish green building sector dynamics and it is also important that legal reforms about the subject should quickly go into effect. Ozcan and Temizbas (2010) list four major problems in green building industry in Turkey:

- Although *CE marking* is a mandatory conformity marking for all construction materials used, it is not regarded in practice or building projects.

- Although products of suppliers certificated under certain standards, products' test results from different time periods may differ from catalogue values.

- Field application is generally of low quality.

- Number of qualified employees in the sector is low.

2.12. International Green Building Performance Assessment Systems

Assessment systems are environmental and management methodologies focusing on the construction sector and targeting to sustainability as well as to social and economic benefits (Papadopoulos and Giama, 2009). They incorporate the experience and information obtained from other environmental methods like decision making and management tools. In this context, many rating systems are based on the concept of life cycle analysis and also include the energy audit part and extend this philosophy to other environmental issues such as water conservation, materials' selection and waste

management. They are another type of scoring systems, based on a standard for environmental performance and designed to evaluate new and existing buildings. Fowler and Rauch (2006) named some principles that must be followed for evaluating and choosing assessment methods:

- Applicability: is the assessment method applicable to all types of buildings such as residential, offices, commercial, hospitals etc.?

- Availability: is the assessment method adaptable to other markets in different countries?

- Measurability: does the assessment method use measurable characteristics to present the extent of sustainable design incorporated into the building?

- Usability: is the method easy to be implemented by the user?

- Technical content: this deals with the environmental aspects investigated during the certification process

- Communicability: what kind of a reporting style does the certification have at the end of the evaluation process?

- System's maturity: this criterion is related to the year of the assessment system's development, final revision and the number of certified buildings

- Development: based on which methodology is the assessment system formed?

- Cost: this is an important criterion to the user and consists of all the costs arising during certification process.

Since different actors who are involved with buildings have different interests and requirements, specific definition of building performance is complicated. For example,

owners tend to focus on economic performance whereas tenants may be concerned with environmental indoor quality and other performance characteristics that directly affect their health and comfort. Besides, operations staff may be concerned with practical issues like maintainability. In this context, there are different measurement techniques to evaluate specific aspects of building performance such as annual energy use, receiving amount of daylight, illumination distribution, annual water use and thermal comfort both during design stage and for existing buildings.

A third party green building rating system may give owners, professionals and tenants the ability to benchmark building design and performance. The general purpose of assessment is to make measurement possible. Whether to differentiate a building or to comply with a government mandate, the more an owner or tenant is able to measure green building performance, the better the a management can do its job. This adoption of standards brings organization and clarity to the greening of construction and building operation with compelling financial savings (Dirksen and McGowan, 2008).

In the real estate market, green building certificates provide information on the environmental performance of a building to owners and tenants. Since it is typically not possible for users to directly measure the desired characteristics such as degree of energy efficiency, environmental performance assessment certification systems provide signals that facilitate the matching of *eco-consumers* to products carrying the desired properties (Fuerst, 2009). Besides, it is widely accepted that eco-consumers' willingness to pay a premium for certified products emerges.

An environmental assessment of a building provides both guidance for remedial work with feedback to design and identifying success at meeting a level of performance. Cole (2010) states that an assessment can:

- gather and organize detailed information on the building that can be used to lower operating costs, lower vacancy rates and increased marketability

- be used by owners to determine priorities for future management measures, retrofits etc. that will keep a property current within a changing marketplace

- provide common and verifiable criteria and targets so that owners striving for higher environmental standards will have a tool of demonstrating that effort

- provide owners a means to communicate to prospective tenants and an important tool for improving public awareness of these matters

- assist in creation of a body of knowledge and expertise within design team and building industry as a whole to facilitate the assimilation of environmental issues

- offer a tool of structuring environmental information for new building designs and major renovations and provides a reference by that owners and architects can formulate effective sustainable design strategies.

The range of environmental criteria is quite wide and any attempt to generate design guidelines or undertake a comprehensive assessment must be preceded by characterization of this range. Although it is relatively simple to list environmental criteria, organizing them into related categories and prioritizing them for design is more problematic. The number, organization of criteria and effort applied to the formulation in assessment methods are influenced by (Cole, 2010):

- the cost and practicality of making an assessment: the larger the number of criteria, the larger the effort required to collect and analyze the results

- whether there is general agreement over the criteria and also confidence as to their significance.

- the ability of users to understand the results of the assessment: the comprehensiveness of an assessment is improved by increasing the number of

criteria included. In contrast to that, the ability of owners or tenants to interpret the results diminishes with each additional criterion.

- the ability to assess the buildings repeatedly and reliably by trained professionals through self-assessment: the reliability of an assessment methodology depends on the consistency of its results, for instance, different assessors of the same building should produce essentially the same performance results.

There are several environmental methods for evaluating environmental performance of buildings. The use and growth of these methodologies are considered to contribute to the integration of tools and implementations favoring sustainability in the construction sector. The available assessment systems worldwide are built upon various principles and different evaluation tools, data and criteria. Fowler and Rauch (2006) state that there are more than 30 green building assessment systems. Some of them which are members of WGBC and widely accepted as the following: Green Star (Australia), DGNB (Germany), IGBC (India), CASBEE (Japan), BREEAM (the UK), LEED (the USA) and also HQE (France).

All these systems have a common goal that is the environmental evaluation of buildings therefore the main environmental issues investigated in them are listed by Papadopoulos and Giama (2009):

- Site potential investigating the construction site's ecological value, maintaining major ecological systems, minimization of biodiversity etc.

- Energy use, energy efficiency, sub-metering, CO_2 impact of systems etc.

- Land use, previously used land, use of remediate contaminated land when new construction is investigated

- Materials' use aiming recycling, reuse of materials, use of sustainable timber etc.

- Water conservation including criteria for metering, reduction of consumption

- Indoor air quality including criteria for adequate ventilation, lighting, thermal comfort etc.

- Pollution, on site treatment, renewable energy sources, light pollution design, avoid use of ozone depleting substances etc.

- Transport emissions evaluation, alternative transport modes etc.

BREEAM and LEED are the most frequently used green building certification systems in Turkey. Among a total of 66 certified buildings, there are 27 projects certified under BREEAM 39 projects certified under LEED in Turkey by June 2013. The BREEAM is developed by the BRE Ltd in the UK in 1990. It is the most popular European rating system and evaluates the environmental performance of buildings in both the design phase as well as existing buildings. It is separated according to the building type to BREEAM for offices, retail, industrial buildings, schools and health buildings. There are different credits under energy, transport, pollution, materials, water, land use and wellbeing categories. These credits are awarded to each issue according to their performance and added together to produce a single overall score. The building is rated on a scale from pass to excellent. The method is not available to the public and involves the participation of the company and licensed assessors. Hence it makes BREEAM less user friendly since the modification of a variable by the designer is impossible (Sinou and Kyvelou, 2006). As of 2013, over 250,000 buildings have been certified and nearly 40,000 projects are registered for assessment under BREEAM which equates to over one million buildings (BREEAM, 2013).

LEED is another third party certification program overseen by a non-profit organization, the USGBC. The USGBC mission is to promote the design and construction of buildings that are environmentally responsible, profitable and healthy places to live and work. It promotes a whole-building approach to sustainability by recognizing performance in five categories of human and environmental health: sustainable site development, water

efficiency, energy efficiency, materials selection and indoor environmental quality. Creative strategies that exceed credit requirements or are not recognized in the categories receive points in a separate innovation section. In each category, there are requirements and performance criteria. These requirements are called *prerequisites* that stipulate minimum requirements for achieving certification under a certain rating system. For example, prerequisites for LEED-NC Version 2.2 are construction activity pollution prevention, fundamental commissioning of the building energy systems, storage and collection of recyclables and minimum indoor air quality performance and prerequisites for LEED for Existing Buildings are minimum indoor plumbing fixture and fitting efficiency, energy efficiency best management practices, sustainable purchasing policy, solid waste management policy, outdoor air introduction and exhaust systems, and green cleaning policy whereas minimum energy efficiency performance, refrigerant management and environmental tobacco smoke control are common prerequisites for both rating systems of LEED.

The performance criteria in LEED rating system are called credits and there are numerous credits within the categories that have points assigned to them; the better the building performs the more points it achieves. In order to achieve a point, the applicant must demonstrate compliance with the criterion. A LEED scorecard shows which criteria are fulfilled in the project and how many points are achieved from them. An example of a LEED scorecard of a real project can be seen in Appendix A.

LEED has nine different rating systems: LEED for New Construction and Major Renovations, Existing Buildings: Operations & Maintenance, Commercial Interiors, Core & Shell, Schools, Retail, Healthcare, Homes and Neighborhood Development. Table 2.4. presents the year the rating system was adopted and made available for the public (Dirksen and McGowan, 2008). There are 100 base points; also 6 possible innovation in design and 4 regional priority points. Throughout the nine systems, applicants can achieve four levels of certification depending on their points achieved: certified (40-49 points), silver (50-59 points), gold (60-79 points) and platinum (80 points and above) (USGBC, 2009).

Table 2.4. LEED Rating Systems and Status (Dirksen and McGowan, 2008).

Rating System	Year Adopted	Applicable development
New Construction	2000	Built to suit or occupied
Existing Buildings	2004	Renovations or reposition
Commercial Interiors	2004	Tenants improvements
Core & Shell	2006	Speculative development
Schools	2007	K-12 schools
Homes	January 2008	Single or multi-family homes
Healthcare	(Draft) First comment period closed Spring 2008	Healthcare facilities
Retail: New Construction	(Draft) Second comment period opened Spring 2008	Shopping malls & retail areas
Retail: Commercial Interiors	(Draft) First comment period slated for Summer 2008	Retail interiors
Neighborhood Development	Pilot program closed	Planned developments

There are minimum program requirements (MPRs) that a project must possess in order to be eligible for LEED certification. These requirements serve three goals: to give clear guidance to customers, to reduce challenges that may arise during certification and to protect the integrity of the LEED program. Under these MPRs, projects must comply with environmental laws, minimum floor area requirements, building to site area ratio and occupancy rates, be a complete permanent building or space, use a reasonable site boundary, commit to sharing whole building energy and water usage data (USGBC, 2011).

Since LEED and BREEAM are the most widely used rating systems in Turkey, a comparison of both assessment systems' criteria in detail is below stated (Papadopoulos and Giama, 2009):

- Water efficiency criteria examine exactly the same parameters in both systems.

- Sustainable site category for LEED includes the same criteria as Ecology for BREEAM guide. One difference is that sustainable site for LEED includes transportation criterion while in BREEAM there is a different category that examines this criterion. The main purpose of this criterion is to reduce pollution

from construction activities by controlling waterway sedimentation, soil erosion and airborne dust generation.

- Energy and atmosphere category refers for both LEED and BREEAM to the same criteria. The difference is that in addition to LEED, BREEAM examines three more parameters: insulator global warming potential, eco-labeled goods and internal and external lighting.

- When materials category is concerned, BREEAM includes some additional criteria: environmental impact of materials and taking account of the full life cycle and responsible sourcing of materials.

- In both guides the issues of internal air quality and comfort is dealt with.

- Management criteria are included only in the BREEAM evaluation process.

Although both LEED and BREEAM building environmental performance assessment systems are widely used all over the world, certain difficulties occur when they are performed outside of the USA and the UK since the specifications of them were prepared according to cultural, economic and geographical conditions of these two countries. Some of these difficulties encountered in Turkey are listed as below (*Yilmaz et al*., 2010):

- Some referred standards and regulations do not match up with Turkish ones.

- There is lack of professionals who know referred foreign sources and standards

- There are barriers in getting a bank loan especially for energy and material implementations. For example, both in BREEAM and LEED standards, wooden parts of the buildings must be certified under FSC or such like. However, it is hard to find products with FSC certificates in Turkey.

- All referred standards and guidelines are written in English. Besides, all drawings, proofs and documents must be submitted by the applicant in English language which causes extra efforts.

It is also stated in the same research that green building concept is very new in Turkey and because of that there are some difficulties such as lack of environmental awareness, lack of internalizing green building projects by key parties, lack of management patterns appropriate for both green project design and construction and inappropriate choice of project delivery systems.

3. RESEARCH METHODOLGY

Two research methods are applied in this study and they are:

- Critical review of the literature
- Case studies

In a research, it is important to review other researchers' experience, methods, design, findings and opinions related to similar problems. Their views based on the results of these relevant studies are organized and presented in a systematic way in the related section of this study.

Since the main research method in this work is case study, it is explained in detail in this section of the thesis. First, the literature was reviewed in order to find examples of definition of case studies. Then comparison between qualitative and quantitative research methods were made, advantages and disadvantages of case studies are presented. Certain requirements when conducting a case study are also listed and explained. Finally, steps of designing and implementing of a case study are mentioned. Interviews within the case studies were another important research tool that was used to gain a better understanding of green building projects in Turkey. An efficient interview easily leads to targeted information and more. List of interviews made for this research is also presented in the following sections.

3.1. Definition of Case Study

There are different views about the definition of case study in the literature. A case study provides detail, completeness, richness and depth for the unit of study. Merriam Webster Dictionary (2013) defines a case study as follows:

> *"Case study is an intensive analysis of an individual unit (as a person or community) stressing developmental factors in relation to environment."*

Another definition made by Schramm (1971, cited in Yin 1989: 22-23):

> *"The essence of a case study, the central tendency among all types of case, is that it tries to illuminate a decision or set of decisions: why they were taken, how they were implemented and with what result."*

According to this definition, decisions are the major focus of case studies. Alternatively, some academicians do not consider the case study a formal research method but consider it as the exploratory phase of a different type of research strategy. There are many examples of common misunderstandings about case study methodology in the literature. One example is the meaning of case study in Dictionary of Sociology (Abercrombie *et al*., 1984):

> *"The detailed examination of a single example of a class of phenomena, a case study cannot provide reliable information about the broader class, but it may be useful in the preliminary stages of an investigation since it provides hypotheses which may be tested systematically with a larger number of cases."*

Flyvbjerg (2006) finds above mentioned definition indicative of much conventional wisdom about case study research and so oversimplified as to be grossly misleading. According to him, this definition promotes the mistaken view that the case study is hardly a strategy but is best seen as subordinate to investigations of larger samples. The definition also blocks the complementarity that exists between the two types of methodology, case studies and statistical methods. This complementarity will be presented in the next sections of this chapter.

According to Yin (2009), the first form of the cases is a study case and the second is the case for research. There are two different views that are implemented for the two types:

> *"A case study is an empirical inquiry that investigates a contemporary phenomenon in depth and within its real life context, especially when the boundaries between phenomenon and context are not clearly evident."*

> *"The case study inquiry copes with the technical distinctive situation in which there will be many more variables of interest than data points as one result relies on multiple sources of evidence with data needing to converge in a triangulating fashion and as another result benefits from the prior development of theoretical propositions to guide data collection and analysis."*

The case study is a research strategy covering the logic of design, data collection techniques and specific approaches to data analysis (Yin, 2003). In this context, the case study is neither a data collection method nor a design feature alone (Stoecker, 1991) but a comprehensive research strategy.

3.2. The Case Study as a Research Method

The case study is a very popular qualitative research strategy in different sciences. It is usually used to investigate real life phenomena and to support decision making. Due to their characteristics, case studies are more of exploratory nature and rather focusing on developing a hypothesis than on testing the theory (Thies and Volland, 2010). Yin (2003) states that there are three types of case studies that can be used:

1. Explanatory case studies are used for causal researches. They investigate an event and its interrelationships in depth.

2. Exploratory case studies aim to explore a new research area when the question is not clear. They serve as motivation and define hypotheses.

3. Descriptive case studies obtain information on particular properties of an issue. A phenomenon is described in detail and investigated then.

Yin (2003) proposed a table in order to present relevant situations for different research methods explicitly. According to the table, there are three conditions consisting of type of research question asked, extent of control the researcher has over actual events and degree of focus on contemporary as opposed to past events. Table 3.1. shows these three conditions and how they are related to five different research strategies: experiments, surveys, archival analyses, histories and case studies.

Table 3.1. Relevant situations for different research methods (Yin, 2003).

Strategy	**Research Question**	**Control of Events**	**Focus on Contemporary Events**
Experiment	how, why	Yes	Yes
Survey	who, what, where, how many, how much	No	Yes
Archival Analysis	who, what, where, how many, how much	No	Yes / No
History	how, why	No	No
Case Study	how, why	No	Yes

The most important condition for differentiating among various research methods is to determine the question being asked. It is seen from the table that if research that asks *who* and *where* research questions are usually to support survey methods or analysis of archival records as in economic research. These two methods are advantageous when the research aim is to describe the effect of predominance of a phenomenon or when it is to be estimated about certain events. A typical example would be surveys conducted in order to find political attitudes. In contrast to *who* and *where* questions, *how* and *why* questions are more explanatory and usually used in histories, experiments and also case studies. These questions deal with operational links that have to be monitored over time rather than frequencies.

A further differentiation among research strategies is the extent of the investigator's control over and access to behavioral events. For example, histories are used as research strategy when there is no access or control of behavioral events. History deals with the past however case studies are preferred in investigating contemporary events. History and case

study have very similar research techniques however there are two additional sources of evidence that are usually not included in historians' methods: interviews with people involved in events and opportunity for direct observation of the events being investigated. Although techniques of case study and history may overlap, the case study's strength comes from its wide variety of evidence including documents, interviews and observations (Yin, 2003).

The last major distinction among research strategies is between the case study and the experiment methods: the investigator in an experiment can manipulate the events directly and systematically. This can happen in laboratory environment by controlling all variables or in the field by treating subjects in different ways whereas relevant behaviors cannot be manipulated in case studies.

To sum up, Yin (2003) states that since case study method has distinct advantages as a research strategy, it is used to identify some situations when:

> *"A how or why question is being asked about a contemporary set of events over which the investigator has little or no control."*

Since the answers of questions *how* and *why* are sought in this research, case studies are the proper research strategy to be implemented in this thesis. It is aimed to explain decisions by finding reasons of them. There is no control of events in this research and this leads the researcher to case studies. The main focus was on contemporary events during the whole investigation process.

3.3. Strengths and Weaknesses of Case Study

According to Siggelkow (2007) there are three major applications for case studies that can be counted as strengths of this type of research methodology:

1. An illustrative instrument: concrete examples of theoretical knowledge lead to that the readers easily understand the conceptual arguments. Case data provides a more

convincing argument about causal relationships than pure theory or empirical research can.

2. Motivating the research question: argumentation in a real life context makes a case a more convincing argument than a pure theoretical motivation.

3. Inspiration for new ideas: real life cases provide rich data. They may be used as tools to strength existing theory, especially in cases where limited theoretical knowledge exists.

In spite of these, there are also certain risks that case studies have:

1. If the number of cases is small then it is generally not a representative for a specific population, hence case studies cannot make use of statistical tests for significance.

2. In some situations, results from case studies may seem obvious to readers. This is called *the problem of ex-post obviousness.*

3. Case studies may quickly become too rich in detail and hence may not generate a useful theory. So it is important not to cause an over determination in the case study.

Flyvbjerg (2011) establishes a table presenting different characteristics of case studies and statistical methods and compare them in order to prove that there is a strict complementarity between these two research strategies. By looking at Table 3.2., some other strengths and weaknesses of case study method can be seen. The table also shows that if a phenomenon in any degree of thoroughness is sought, case study method should be pursued. On the other hand, if how widespread the phenomenon is and how it correlates with other phenomena is sought then statistical studies should be done.

Table 3.2. Complementarity of case studies and statistical methods (Flyvbjerg, 2011).

	Case Studies	Statistical Methods
Strengths	Depth	Breadth
	High conceptual validity	Understanding how widespread a phenomenon is across a population
	Understanding of context and process	Measures of correlation for populations of cases
	Understanding of what causes a phenomenon linking causes and outcomes	Establishment of probabilistic level of confidence
	Fostering new hypotheses and new research questions	
Weaknesses	Selection bias may overstate or understate relationships	Conceptual stretching by grouping together dissimilar cases to get larger samples
	Weak understanding of occurrence in population of phenomena under study	Weak understanding of context, process and causal mechanisms
	Statistical significance often unknown or unclear	Correlation does not imply causation
		Weak mechanisms for fostering new hypotheses

3.4. Requirements of Case Studies

A research must represent a logical set of statements and any given design according to certain logical tests must be proved. It is also important to meet certain requirements when performing a case study. Yin (2003) addresses that following four criteria ensure that the case study is credible and persuasive from a methodological point of view: construct validity, internal validity, external validity and reliability.

1. Construct validity is related to the quality of operationalization of the concept being investigated. To meet the requirement of construct validity, a researcher must use multiple source of evidence, form a chain of evidence and adopt different point of views in order to look at the phenomenon from different perspectives.

2. Internal validity refers to only explanatory case studies in which an investigator determines whether a specific event led to another. If he/she fails in concluding that there is a causal relationship between two events knowing also that a third factor caused this then the research design fails in meeting requirement for internal validity. Establishment of causal relationships can be ensured by clear research frame work, explanation building, pattern matching techniques, rival explanations and use of logical models.

3. Since sufficient statistical generalization is not available for case studies, external validity refers to the problem of knowing if a study's results can be generalized beyond the immediate case study. However, pattern matching techniques that compare models of empirical studies with theories from literature allow analytical generalization. The researcher should provide a clear justification for case study selection. A theory must be tested by replicating the results in a second or third environment where the theory shows that the same results must occur.

4. In order to meet reliability requirement, an investigator who followed the same procedures as described by an earlier investigator and conducted the same case study should arrive at the same results and conclusions with the earlier one. Briefly, the study must be without random error which means it can be repeated with the same results. The aim is to minimize errors and biases in a study. Reliability can be provided by transparency through clarification of research procedure and replication through a case study database.

To sum up, four aforementioned tests are considered relevant in evaluating the quality of a case study research design. These tests and recommended case study tactics are listed in Table 3.3. (Yin, 2003). In case studies of this thesis, both archival records and interviews are used during data collection phase in order to satisfy the construct validity. A research framework which is explained in next sections and used to analyze the cases was established based on literature in order to improve the internal validity. In research design, multiple case studies are selected among certified green building projects and performed in

order to emphasize external validity. To allow replication of the study, a case study database is established so sufficient reliability is aimed to be ensured.

Table 3.3. Case study tactics for four design tests (Yin, 2003).

Tests	Case Study Tactic	Phase of Research in which Tactic Occurs
Construct Validity	Use multiple sources of evidence Establish chain of evidence Have key informants review draft case study report	data collection data collection composition
Internal Validity	Do pattern matching Do explanation building Address rival explanations Use logic models	data analysis data analysis data analysis data analysis
External Validity	Use theory in single case studies Use replication logic in multiple case studies	research design research design
Reliability	Use cases study protocol Develop case study database	data collection data collection

3.5. Sources of Data

There are two main information resources in case studies: primary information and secondary information. Primary one consists of any documents about the subject like reports, forms and letters. Archives such as project drawings and name lists are also examples of primary information. On the other hand, interviews made with project personnel or clients are in class of secondary information that also provides direct observations about the subject. Yin (2009) defines sources that the investigator makes use of:

1. *Interview* is the first data source that can be used in case study research method. It is accepted as a qualitative form of data. The researcher has to organize and then analyze the collected data. Open interviews, semi structured interviews and structured interviews are the three types of this source. Case questions are the advantage of interviews and lead to causal actions and references. The disadvantage

of interviews is that the data may be biased due to badly formed questions and it may also occur that the interviewer may get the data he/she wants to hear.

2. *Documentation* can be diagrams, reports, documents, contracts and memos etc. Since this source is rarely created for the sake of a case study, the data can give the researcher a better overview of the situation in the case. However, the relevant reports and references can be hard to find among many other documents.

3. *Archives* are precise and quantitative and do not have to be within the organization. They can be provided from other resources. They have similar advantages and disadvantages as the documentation. Besides, they may have limited access due to privacy reasons.

4. *Direct observation* is based on that the researcher is someone out of the case organization and can observe extrinsically what happens within the case using. The researcher's judgment is decisive in choosing what is needed to continue the study. However, this may lead to that the collected data may be biased because of the subjective judgment. Besides, participant observations have similar properties as direct observations. They are insightful into interpersonal behaviors however they may be biased due to the researcher's manipulation of events.

5. *Physical artifacts* may be a technological device, a tool and an instrument etc. Such evidences may be collected or observed as part of a visit. They have less potential relevance in case studies but when they are relevant, the artifacts can be important components in the overall case. They have two typical disadvantages: availability and selectivity.

3.6. Investigated Projects

During an interview appropriate questions must be asked, interviewees must be listened and understood well. Interviewer must be adaptive and flexible when encountering new and unexpected aspects. Besides, avoiding bias is also another important issue for interviewer to reveal an academic work. Issues being studied must be very well understood by the interviewer. Before conducting such an interview, purpose of study and questions should be clearly stated. Then nominations must be chosen and reviewed. Schedule of visits and an outline of interview report should also be prepared. If needed, some materials related to the topic should also be brought with.

In this thesis, buildings are investigated which are certified in Turkey according to green building criteria of internationally used certification systems. However, research area covers only existing buildings that are upgraded in terms of operation and maintenance or buildings that went through a major renovation. New constructions that are designed according to any green building criteria from scratch are out of the research area. BREEAM and LEED are two well-known organizations in Turkey of which certification systems are widely used. From the buildings of concern, it is seen that there are only buildings with LEED certification that fall into research subject. All buildings certified under BREEAM in Turkey are examples of new constructions.

As of the date of June 2013, there are ten buildings of eight different private companies and a public university that fall into the research area. Six of them are in Istanbul, in the most populated city of the country, two of them are in Kocaeli, in another industrialized zone, one is in Izmir and another one is in Ankara, the capital of Turkey. This information is obtained from LEED's official list of certified green buildings. After determining the buildings of concern, their key personnel had to be reached. Clients, project managers, project developers, architects, design engineers, site engineers, consultants or LEED APs in charge of the project are examples of mentioned key personnel.

During research, by using personal network or available contact information, executives of the companies or officers of the institute were reached. Each of them was asked for a face to face interview on a suitable date. It was explained to each contact person that this was an investigation of existing green buildings hence the number of nominate buildings was limited and so their help was crucial. All of the contacted persons were helpful. They wanted to give available information to be used in an academic study. In addition, some of them requested the result of the study when completed since they believe that they will benefit from it for both their personal purposes and their companies or institute.

Interviews were made in green buildings that are being investigated in this study. This provided that structures were good to be inspected in their own places and gave a chance of direct observation. Interviews were recorded with a tape recorder to ease remembering what was spoken. Written, visual and numerical data were also taken from interviewees. Some of them gave their project presentation files, some shared photos from the building's construction phase and there were also persons who gave their speech texts from symposiums and conferences about green buildings that they attended. Each interview took at least 60 minutes and a maximum of 90 minutes. In all cases, at least two individuals were interviewed either at the same time or at different times. One of the interviews was made with three key personnel at one session. It is expected that different aspects of a specific project are helpful for preventing possible biases.

In Tables 3.4. and 3.5., each project and corresponding interviewee information can be found. Interviewees are denoted with numbers starting from 1 and companies or buildings with capitals starting from A. Besides, consultant firms are named with Roman numerals starting from I. Each interviewee's duty in his/her company or in the project is shown in the tables. The building's location, type, LEED certificate type and certification year are also shown.

Table 3.4. Project properties that were investigated in the study.

No	Location	LEED Certificate	Class / Year	Consultant
1	Istanbul / European Side	EB:OM v2009	Silver / 2011	Consulting Firm I
2	Istanbul / European Side	NC v2009	Silver / 2011	Consulting Firm I
3	Istanbul / European Side	NC v2009	Gold / 2012	Consulting Firm II
4	Istanbul / Asian Side	NC v2009	Gold / 2012	Consulting Firm III
5	Ankara	EB:OM v2009	Gold / 2012	Consulting Firm IV
6	Istanbul / Asian Side	EB:OM v2009	Silver / 2013	Consulting Firm I

Table 3.5. Interviewees that contributed to the study.

No	Interviewee	Title	Name	Building Type
1	Interviewee 1	Business Developer	Building A	Headquarters
	Interviewee 2	Business Development Manager		
2	Interviewee 3	Architect M.Sc.	Building B	Hotel
	Interviewee 4	LEED AP		
3	Interviewee 5	Mechanical Engineer M.Sc.	Building C	Dormitory
	Interviewee 6	Architect M.Sc.		
	Interviewee 7	Architect		
	Interviewee 8	LEED AP		
4	Interviewee 9	Administrative Affairs Manager	Building D	Office Building
	Interviewee 10	Architect		
5	Interviewee 11	Technical Manager	Building E	Headquarters
	Interviewee 12	Electrician		
6	Interviewee 13	Director of Administrative Services	Building F	Office Building
	Interviewee 14	LEED AP		

3.7. Research Framework of the Thesis

Ozorhon (2012) developed a framework to analyze the innovation process in a construction project setting by using components like drivers, inputs, barriers, enablers, innovative activities and outputs. Based on that previous framework, a similar framework is formed to investigate green building projects in Turkey. The proposed framework can be seen in Figure 3.1. According to the framework, drivers and resources lead owners or tenants to apply green building energy efficient implementations. During implementation

stage, barriers and enablers are encountered. After the project is completed, negative or positive benefits occur both at organization and project level. Independent of being successful or unsuccessful, lessons learned from each unique project process occur at the end of this process.

A semi-structured interview form was constructed to be applied in all interviews in this study. In a semi-structured type of interview, the interviewer constructs a manuscript to stick to during the interviews. Instead of a structured form, a semi-structured one was preferred because this kind provides more area to be investigated. When using a structured

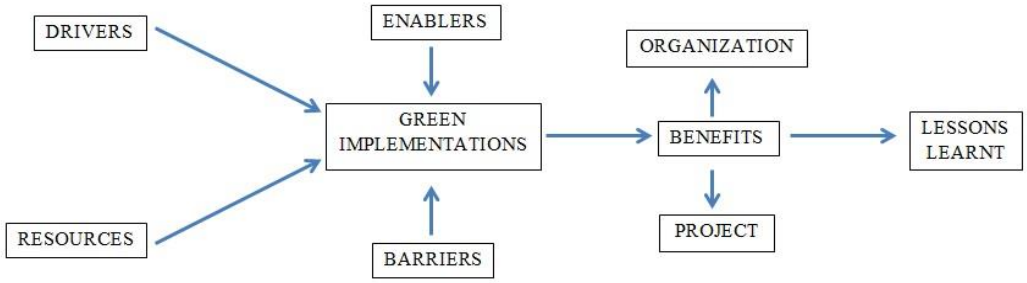

Figure 3.1. Framework to investigate greening projects in this research.

form, the interviewer's investigation area is limited with only given issues. However, during a semi-structured interview, it is very common that an interviewee puts extra information in the interview which makes the case based on stronger foundations. Besides, instead of a non-structured interview form, a semi-structured one was preferred since there must be a common form which can be used during all interviews so that they can be compared with each other in discussion part. The semi-structured interview form consisted of the following questions:

1. What are the general *properties* of the project and the organization?

2. What were the *reasons or drivers* for greening the building and applying for LEED certification?

3. What kind of *resources* was used during the whole process?

4. What type of energy efficient *tools* were implemented in the project?

5. What were the *barriers* that were encountered?

6. What were the *enablers* to overcome those barriers?

7. What are the benefits and *outcomes* of the project?

8. What are the *benefits* of the project at organization level?

9. What *lessons* were learned after all project management, construction, application and certification processes?

The drivers of each project, their results and how the processes were managed are investigated in the research. In the first question general information about the building and the project are sought. Information is given about year of erection of the building, year of renovation, total LEED points, certification class and type, date of application and date of certification, number of people living or working in the structure, its facilities, total construction area of the building, scope of the company or the institute and consulting firm during application period. In the second question, it is explored the companies decide to turn their buildings into a green one and then apply for a LEED certificate. Clients' and architects' considerations about green building concept are sought in this part. Company's social and environmental responsibility policy, client's expectations and path to the start point of the project are explained in this part. Financial, material and human resources used in the project are asked in the third question. Research and development works of the company for green buildings, information used during the process, total cost of the renovation and incremental cost of LEED application process, time consumed to complete the project and procurement locations are questioned. Also information about availability of environmental friendly material suppliers in Turkey is achieved. Subsequently, in the fourth question, types of energy efficient tools that were adopted in the projects are

examined. In the fifth one, any barriers met during both constructional and bureaucratic processes are explained. They may be cultural, financial, technical, conceptual or unexpected barriers. There are also barriers related to labor force or material supply. In sixth question it is looked for how these aforementioned barriers are overcome. These problems can be solved by leadership, good management, resource allocation, value engineering, special training, using technical knowledge or financial resources, receiving support from the consulting firm or help from material suppliers, taking advantage of the building's existing properties and employing experts or qualified personnel. When the project is completed, benefits provided from the new green building are observed by both users and the project team. These benefits are arrayed in the seventh question. These are savings in electricity, water and gas consumption, increase in motivation of work force and internal environment quality and also reduction in emission of gases and operating costs. In the eighth question, benefits of the project in organization level are sought. Gaining experience in green building concept and being a pioneer in this very new area in Turkey, improving recognition of the organization by behaving in direction of environmental responsibility policy, enhancing the company's brand value in the market and winning awards both in national and international platforms are examples for benefits at corporate level. The ninth and last question is about lessons learned from the project. Critical success factors are searched during this question.

Questions were asked to the interviewees in the order as they are presented above, i.e. beginning from the first one and ending with the ninth one. However, during some interviews sequence of questions was not followed since answers from the interviewees changed the way of conversation as expected. This may happen in a semi structured interview manner. The aforementioned nine questions are not only used for conducting the interviews but they also comprise the nine main titles that are used to analyze each case study in this academic work.

4. CASE STUDIES

4.1. Case 1

4.1.1. General Information

Owner of Building A is a private firm which operates in construction and energy sector in Turkey. It was founded in 1961 and is a member of TCA. The company was ranked several times in *ENR Top 225 International Contractors* list. They construct and sell building complexes that are certified under LEED. They have a strong sustainability policy and call themselves aware of environmental issues.

The company's headquarters building was built in Istanbul in 1987 and it was renovated in the year 2008. It is a reinforced concrete structure and a 6-storey building which has a construction area of 7.500 m^2. There are storerooms, one dining hall, one installation room, one garage, one mezzanine, a doctor room and a terrace in the building. There are 288 employees working inside.

In June 2010 executives of the company decided to apply for a certification under *LEED for Existing Buildings: Operations and Maintenance*. A silver LEED certificate with 55 points was aimed. At first, observations and tests were made in the headquarters building and deficiencies were determined. Then necessary improvements were made and documentations were prepared. In April 2011, the documents were sent to the USA. When the response letter arrived, it was understood that there were unclear parts that LEED officers wanted to be clarified. Documents were corrected and sent back to the USA in July. In August 2011, Building A was certified under LEED for Existing Buildings Operations & Maintenance (version 2009) with 53 points (silver certificate).

4.1.2. Drivers

The company is one of a few pioneer firms in Turkey that strongly aim to raise environmental awareness in the country. In 2006 they prepared and published the

S*ustainable Life Report* which made a powerful impression in Turkish construction sector. In the report it was referred to global warming and green buildings. In 2011 they published the second report which revealed sources of greenhouse gas emissions of their headquarters building in Istanbul.

The company undertakes corporate social responsibility projects about energy and water savings. They replace old style faucets in public schools with efficient water armatures. They are a member of the CEDBIK and also support nongovernmental organizations that work on sustainability. Besides, they continuously develop LEED nominate housing projects. Since the company already owns certificates of ISO 14001 which is the standard for environmental management systems, OHSAS 18001 which is the standard for occupational health and safety management systems and ISO 14064 which is the standard for greenhouse gas emissions verification systems, it was not hard to adapt to high environmental standards. EFQM Excellence Model was also applied in the company.

All above mentioned actions of the company about protecting the nature and creating environmental awareness resulted in certificating their central office building. Besides, Interviewee 1 adds that it was also aimed to raise employee comfort in the building and to provide that the structure can catch the era during the process of adaptation.

4.1.3. Resources

Real estate development team of the company was in charge of LEED certification process. They sometimes worked together with electrical, architectural and mechanical teams of the firm. Interviewee 1 was the leader of the project who coordinated the teams and made all the documents prepared. She worked at real estate development manager's service. During certification process, they also continued their routine operations. Research & development works of the project were also conducted by them.

Consulting Firm I was chosen as LEED consultant during the process. Consulting Firm I assisted the company especially in ASHRAE energy survey. They modeled the

whole building in order to calculate its water and energy consumptions so that saving values were projected.

Since the headquarters building went through a major renovation before LEED certification process, there was no need to spend much money in order to convert the building to a green one. Improvement and documentation works took almost ten months.

4.1.4. Tools

Table 4.1. LEED scorecard summary of Building A.

LEED-EB 2009 Credits for Building A			
Categories	**Possible Points**	**Points Applied for**	**Points Won**
Sustainable Sites	26	17	17
Water Efficiency	14	11	9
Energy and Atmosphere	35	13	13
Materials and Resources	10	7	7
Indoor Environmental Quality	15	3	3
Innovation in Operations	6	4	4
Total	**106**	**55**	**53**

There are several green implementations in the building that helped the project team get LEED certification. Some of them and their properties are as the following:

- All investments were chosen so that they had short payback periods.

- Terrace roof of the building is covered with white tiles which reflect the sun light and prevents warming of the roof. Additionally, on the firm ground around the building light colored tiles with high solar reflectance index were preferred so that heat island effect was removed.



Figure 4.1. White tiles on the roof.



Figure 4.2. White roof.

- An operation and maintenance schedule is formed. According to this plan, all systems and devices in the building undergo a technical control before their maintenance date comes so that they do not break down unexpectedly. Management plan of the building was changed. Interior temperature preference in winter was 22˚ C and it was adjusted to 20˚ C. Besides, interior temperature in summer was some degrees increased. Table 4.2. is a shortened part of the schedule.

Table 4.2. Operation and maintenance schedule of Building A.

Equipment	**Place**	**Power [kW]**	**Cycle [month]**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Chiller Pump 1	Boiler Room	4	12					x							
Boiler Pump 1	Boiler Room	1	12										x		
Fire Hydrophore 1	Boiler Room	5.5	12					x							
Hydrophore 1	Water Tank Room	3	12					x							
Boiler 2	Boiler Room	2	12										x		
Split Air Conditioner 1	Drivers Room	2.7	12					x							
Ventilation	Garage	2.2	12					x							
Split Air Conditioner	UPS Room	5.3	3	x			x			x			x		

Table 4.2. Operation and maintenance schedule of Building A (cont.).

Aspirator 1	Basement	0.2	6						x						x
Refrigerator 1	Basement	0.9	6						x						x
Refrigerator (No Frost) 1	Garage Tea Room	1.7	6						x						x
Grill	Dining Hall	12	6						x						x
Water Boiler	Dining Hall	18	6						x						x
Brazier	Dining Hall	33	6						x						x
Heated Tilting Pan	Dining Hall	9	6						x						x
Cupboard	Dining Hall	0.6	6						x						x
Convection Oven	Dining Hall	51	6						x						x
Mincing Machine	Dining Hall	1.5	6						x						x
Blender	Dining Hall	1.1	6						x						x
Water Bath	Dining Hall	1	6						x						x
Refrigerated Display Cabinet	Dining Hall	1	6						x						x
Dishwashing Machine 1	Dining Hall	12.4	6						x						x
Deep Freezer 1	Dining Hall	5	6						x						x
Generator 1	Ground Floor	300	1	x	x	x	x	x	x	x	x	x	x	x	x
Ventilation (WC)	Terrace	2.2	12				x								
Interior Exhaust	Terrace	2.2	12				x								
Ventilation (Kitchen)	Terrace	3	12				x								
Chiller 1	Terrace	75	4					x			x			x	
Elevator 1	Elevator Room	6.7	1	x	x	x	x	x	x	x	x	x	x	x	x

- There is a strict waste management in the building. Before implementing such a policy, analysis of wastes in the building was performed. During the renovation, all debris was sent to recycling. Besides, all of that, remains of food are sent to animal houses through the municipality.



Figure 4.3. (a) Recycle bin in the office. (b) Waste batteries collection box.

- Water armatures and sanitary system were replaced with economic and efficient ones. There is a small garden of 100 m^2 area in front of the building that is covered with local plants which have been there since 1987. Local plants are easily adapted to existing climate conditions and need less water. This brings water saving in irrigation of the plants. Besides, efficient irrigation methods were chosen.



Figure 4.4. (a) Sensor faucet. (b) Local plants in the garden.

- The location of the building is very central. It is very close to almost all modes of public transportation such as metro, bus, metrobus and minibus. Seventy percent of

the employees come to the building and turn back to their homes by public transport or shuttles. This reduces carbon emissions.

- ASHRAE Level 1 and 2 energy audits and daylight measurements were conducted in the building. According to the results, necessary improvements were performed. In 40% of energy consuming systems of the building, sub-metering devices were set up thus it is possible to compare monthly consumption rates. All heating valves in the engine room were controlled with thermal cameras and heat leakages were detected. Then isolation of the valves was performed with insulating materials wrapping them.

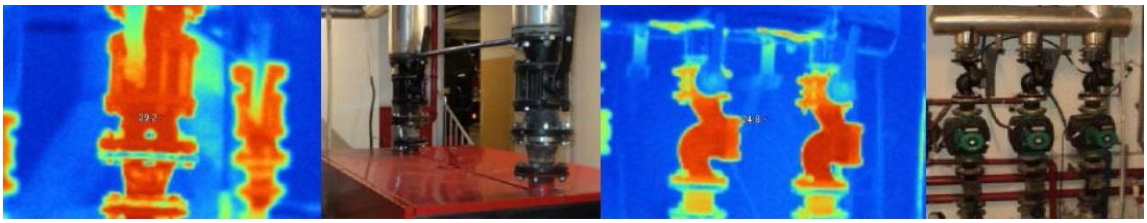

Figure 4.5. Heat leakages in the valves.



Figure 4.6. Isolation of the valves wrapped with insulating material.

- Halide halogens of the signboard in front of the building were replaced by LED bulbs which offer long service life and high energy efficiency. Exterior lighting fixtures were pointing to the sky and this made them inefficient hence they were replaced with efficient ones that were installed with a conical cap and so pointed to

the ground. On the other hand, electronic devices with Energy Star logo were preferred to be used.





Figure 4.7. (a) Old exterior lighting fixtures. (b) New exterior fixture.



Figure 4.8. LED lamps on the ceiling.

- Before renovation, there was natural ventilation in the building: employees used to open the windows when they got warm or wanted to breathe fresh air. Since this was inefficient and insufficient, a mechanical ventilation system was installed in the building. Ozone-friendly gases which are appropriate for Montreal Protocol were chosen to be used in heating and cooling systems. In garage carbon dioxide detectors were placed. When CO_2 amount exceeds a specific amount in the garage then ventilation starts automatically in order to reduce it.





Figure 4.9. (a) Ozone friendly gases in use. (b) Central air conditioning.



Figure 4.10. CO_2 detectors in the garage.



Figure 4.11. Mechanical ventilation system on the floors.

- A sustainable purchasing policy was formed by the business development team. All consumables, lamps and durable goods are purchased according to this policy so that they must be either recycled or recyclable. 87% of electronic materials and 97% of the construction and repair materials used in the building are sustainable.

Additionally a green cleaning policy was established. Cleaning consumables are bought according to it and cleaning personnel were trained.

- No smoking is allowed in the building. Smoking area is eight meters away from it. In front of the entrances, 3 meter long doormats were laid. Thus, incoming people step at least three times on the doormat and leave their dirt and dust outside.



Figure 4.12. 3 meter long doormat in front of the building.

4.1.5. Barriers

When the documents first came back from the USA in 2011, it was mentioned by LEED that the plants in front of the building did not seem to be local. To refute this, the company hired a botanic expert and made him count all the plants in the garden and specify each unique species of them. Then he wrote a report. It was translated by an interpreter, confirmed by the notary and sent back to the USA. Only then LEED was convinced.

The company was following up the water consumption rates monthly before application for LEED. However, the new criteria required a weekly follow up schema. The company could not afford such an effort and the project team gave up 2 LEED points on this matter.

The company and LEED organization were in a strong disagreement about the goods that did not come to end of their economic lives. LEED standards required that LED

lamps should be used in the building however lamps in the building were also energy efficient ones and did not come to end of their economic lives. Replacing them would not be an environmental friendly action so the company refused to use LED lamps instead of the lamps in use although they could not get any LEED points. They added to their purchasing policy that when the lamps in use would come to end of their economic lives then the most energy efficient and environmental friendly lamps would be supplied.

In the USA and Canada there are suppliers that sell LEED approved cleaning consumables. However, the project team could not find such goods for cleaning works in Turkish market. Importing these goods was not feasible so they were not used. Since non-certified goods were not valid to get points in LEED criteria, the company could not get any points in this respect. In spite of this, they decided to use local consumables that were very similar materials to certified ones in the USA and remarked this in their green cleaning policy. Interviewee 1 also adds: *"We had difficulties in reaching goods that were produced from 100% recycled materials."*

Project team looked for a cleaning company that would service according to green building regulations but they could not find any one in Istanbul. *"Facility management sector is still not developed enough in Turkey. Especially cleaning companies are unaware of green concept."* says the interviewee.

Last but not least, it was another difficulty that the documentation had to be written and read in English since LEED is an American organization. This brings the necessity of charging personnel who know English during documentation process. Interviewee 1 says that her business development manager does not believe that every facility manager has to know English. She believes that it is unreasonable to prepare documents in English for a Turkish building.

4.1.6. Enablers

One of the key enablers that made the project successful was cost benefit analysis. The team in charge of the project calculated costs of each tool that could be possibly

implemented and their expected payback periods. After a detailed comparison of each of them, they chose which ones to be applied in the project.

The project team performed essential renovation works on a small scale without attracting any employee's attention in the headquarters building. Interviewee 1 mentions: *"Our co-workers asked us what we were doing since they did not recognize any change during one year."* In fact, all saving measures like low flow water armatures, recycled toilet papers or broadsheets and altered indoor temperature did not disturb the personnel. No disruption occurred in routine operations and no one's comfort was spoiled during adaptations in the building.

The main principle of the project team was to internalize the green building concept during green building implementation process. Interviewee 1 says that it is not correct to green a building only for being certificated, in the contrary the process must be carried out with environmental responsibility. Without self-devotion, process could lengthen out. Moreover, the project won extra points in extra performance title: According to LEED evaluation, there were 87% exemplary performance in sustainable purchasing and 40% in water efficiency. In addition to these, the project got 77 points in Energy Star system although getting only 69 points was sufficient for LEED.

The project team was continuously supported by the senior management of the company and other teams within the company were also very helpful to the business development team. All these enablers accelerated the conversion process.

4.1.7. Benefits at Project Level

According to data Interviewee 1 recorded, in 2010 and 2011 12.310 kg of paper; 20 kg of plastic; 150 kg of metal; 1350 kg of debris; 105 kg of glass and 20 kg of batteries were delivered to the municipality in order to be treated. They were used in producing recycling materials.

Heating and cooling, air conditioning and lighting values before and after LEED implementation are listed in Table 4.3. and 4.4. It is seen from the tables that heating temperatures in winter were decreased deliberately and there is more fresh air in the office floors owing to new mechanical ventilating system. Besides, light intensity in the building was optimized by taking into consideration of brightness necessities.

Table 4.3. System data before green building implementations.

Requirement	**BEFORE LEED**					
	Office		**Restaurant**		**Kitchen**	
	Occupied	Unoccupied	Occupied	Unoccupied	Occupied	Unoccupied
Heating	22˚C	16˚C	22˚C	16˚C	20˚C	16˚C
Cooling	24˚C	28˚C	24˚C	28˚C	N/A	N/A
Exhaust	5134 m^3/h	Off	N/A	Off	5084 m^3/h	Off
Ventilating	Natural	Off	1958 m^3/h	Off	Natural	Off
Humidity Control	N/A	N/A	N/A	N/A	N/A	N/A
Pressure	14750 m^3/h	Off	Positive	Off	Negative	Off
Lighting	200-600 Lux	Off	130-200 Lux	Off	145-250 Lux	Off
Filtration	N/A	N/A	N/A	N/A	N/A	N/A

Table 4.4. System data after green building implementations.

Requirement	**AFTER LEED**					
	Office		**Restaurant**		**Kitchen**	
	Occupied	Unoccupied	Occupied	Unoccupied	Occupied	Unoccupied
Heating	20˚C	16˚C	20˚C	16˚C	18˚C	16˚C
Cooling	24˚C	28˚C	24˚C	28˚C	N/A	N/A
Exhaust	5134 m^3/h	Off	1500 m^3/h	Off	5084 m^3/h	Off
Ventilating	25% Fresh Air	Off	1958 m^3/h	Off	Natural	Off
Humidity Control	50%	Off	50%	Off	N/A	N/A
Pressure	Positive	Off	Positive	Off	Negative	Off
Lighting	400-500 Lux	Off	150-200 Lux	Off	250 Lux	Off
Filtration	EU4 & EU9	Off	EU4 & EU10	Off	Metal	Off

Table 4.5. Mechanical systems and their unit types.

Requirement	Units	Automatic Control
Heating	FCU	CP
Cooling	FCU	CP
Exhaust	EF	On / Off
Ventilating	AHU	CP
Humidity Control	N/A	N/A
Pressure	EF & AHU	On / Off
Lighting	Fixtures	On / Off
Filtration	EF & AHU	N/A

Savings in electricity, water and gas consumptions are listed in the Tables 4.6., 4.7., 4.8., 4.9., 4.10. and 4.11. When looked at consumption rates between 2005 and 2011, it appears that there are fluctuations in both total consumption and consumption per person rates. However, when tables are formed which are used for comparing consumption rates that were obtained just before and after energy efficient tools were implemented in the building, it is seen that there are savings in all consumption rates as gas, water and electricity consumptions.

Table 4.6. Yearly electric consumption rates.

Years	Personnel	Total Electric Consumption [kWh]			Electric Consumption per Person [kWh]			Saving [%]
		Winter	Summer	Total	Winter	Summer	Total	
2005	200	218.700	456,300	675,000	1,094	2,282	3,376	-
2006	200	227,500	452,900	680,400	1,138	2,265	3,403	-0.8
2007	200	269,800	519,200	789,000	1,349	2,596	3,945	-15.9
2008	200	317,000	564,200	881,200	1,585	2,821	4,406	-11.7
2009	200	315,268	495,657	810,925	1,576	2,478	4,054	8.0
2010	266	329,389	611,057	940,446	1,238	2,297	3,535	12.8
2011	288	412,361	688,786	1,101,147	1,432	2,392	3,824	-8.2

Table 4.7. Yearly electric savings.

Years	Personnel	Expected Consumption [kWh]	Actual Consumption [kWh]	Decrease [%]
2009	200	810,925	810,925	0.0
2010	266	1,078,530	940,446	12.8
2011	288	1,167,732	1,101,147	5.7

Table 4.8. Yearly gas consumption rates.

Years	Personnel	Total Gas Consumption [m^3]			Gas Consumption / Person [m^3]			Saving [%]
		Winter	Summer	Total	Winter	Summer	Total	
2005	200	21,605	5,191	26,796	108	26	134	-
2006	200	20,759	9,748	30,507	104	49	153	-13.8
2007	200	13,963	9,396	23,359	70	47	117	23.4
2008	200	25,854	9,968	35,822	129	50	179	-53.3
2009	200	22,097	3,312	25,409	110	17	127	29.1
2010	266	21,132	4,053	25,185	79	15	95	25.5
2011	288	23,206	4,260	27,466	81	15	95	-0.7

Table 4.9. Yearly gas savings.

Years	Personnel	Expected Consumption [m^3]	Actual Consumption [m^3]	Decrease [%]
2009	200	25,409	25,409	-
2010	266	33,794	25,185	25.5
2011	288	36,589	27,466	24.9

Table 4.10. Yearly water use.

Years	Personnel	Water Consumption [m^3]			Water Consumption / Person [m^3]			Saving [%]
		Winter	Summer	Total	Winter	Summer	Total	
2005	200	1,382	2,289	3,671	6.9	11.5	18.4	-
2006	200	1,661	2,267	3,928	8.3	11.3	19.7	-7.0
2007	200	1,261	2,261	3,522	6.3	11.3	17.6	10.3
2008	200	2,036	1,817	3,853	10.2	9.1	19.3	-9.4
2009	200	1,154	2,659	3,813	5.8	13.3	19.1	1.0
2010	266	1,976	2,840	4,816	7.4	10.7	18.1	5.0
2011	288	2,014	2,892	4,906	7.0	10.0	17.0	6.0

Table 4.11. Yearly water savings.

Years	Personnel	Expected Consumption [m^3]	Actual Consumption [m^3]	Decrease [%]
2009	200	3,813	3,813	0
2010	266	5,071	4,816	5
2011	288	5,491	4,906	11

When consumption rates per person in the years between 2009 and 2011 are compared, it is seen that, when rates in 2009 were used as baseline, consumption rates decreased after LEED implementations. Only in 2011, amount of decrease in electric consumption was decreased. This is because mechanical ventilation system was installed in the building in that year.

The company conducted an employee satisfaction questionnaire among its employees in the building. The results are shown in Table 4.12. It is seen that employee satisfaction increased after the conversion process. There is a high amount of increase especially in thermal and acoustic comfort in the headquarters building. Lastly, according to what Interviewee 1 says, it is estimated that carbon emission of the building decreased after energy efficient tools were implemented but it cannot be measured.

Table 4.12. Results of employee satisfaction survey.

	Satisfaction [%]	
	2010	2011
Thermal Comfort	44	63
Acoustic Comfort	21	39
Internal Air Quality	74	76
Lighting Level	22	35
Cleanliness	75	83

4.1.8. Benefits at Organization Level

The building is the first one in Turkey that was certified under LEED for Existing Buildings Operations & Maintenance. This is on its own a considerable success and brings prestige to the firm. Recognition and prestige are hard concepts to be measured but company officials believe that brand value of the firm increased with this certificate. Besides, such an effort is in total compliance with the company's vision and environmental responsibility policy.

4.1.9. Lessons Learned

Based upon her experiences, Interviewee 1 says that it is very easy and low cost to convert existing buildings to green buildings. In spite of the general opinion that being green is expensive, the company finished this conversion process with small and efficient investments and critical adaptations in building management and daily operations. Building management skills play key role in conversion of existing buildings into green ones.

Interviewee 1 and 2 say: *"You cannot be green unless you internalize it!"*. They even resisted LEED's demands when they thought that what demanded was not feasible for their project. They cared about being green more than being certificated. To follow LEED's instructions without any environmental awareness would not be the right way.

Since LEED is an organization located in America, sending and receiving of documents take months since and this prolongs the period of certification for which the clients are impatient. The more it takes, the more man hours are needed. Since all LEED documents are in English, whole Turkish documents must be translated into English language. All these efforts cost time and money. Besides, the business development manager of the company believes that a building manager or user should be able to convert his / her building to a green one without having to know English.

4.2. Case 2

4.2.1. General Information

Building B is the first heritage building in Turkey that is certified under LEED after a major renovation work. It serves now as a hotel and was built in the late 1880's. The building is 6-storey, has a construction area of 330 m^2 and located in Istanbul. It is a second degree historical monument and when it was first bought by its current owners several years ago, it was about to collapse. Afterwards it was renovated according to sustainable architecture requirements and certified under LEED for New Construction and Major Renovations (version 2009) with 55 points in 2011 and gained a LEED silver certificate.





Figure 4.13. (a) Outside view of the hotel. (b) The hotel's lateral section.

4.2.2. Drivers

Owners of the hotel are highly trained persons and respect the environment. They also wanted to begin a business for their daughter who was a returnee from the USA. Before the renovation began, Interviewee 3, the architect of the project, offered project owners the LEED certification. They answered in the affirmative. Interviewee 3 says: "*I was surprised because owners in Turkey characteristically refuse such offers by virtue of expecting higher costs."* She explained to them green buildings were our age's need and adds: *"Making green is not as costly as people are afraid of. I am grateful to the owners."*

Life cycle analysis of the building was performed and it was seen that if green building investment would be made in the renovation project then its return would be large with an expected lifetime of 100 years. Restoration projects are inherently slow going ones when compared to other construction projects. Therefore, converting Building B into a green building would not add extra time to the project schedule. Besides, fulfilling essential requirements of sustainable architecture is easier in renovation works. All these factors led to that the owners were convinced easily.

Interviewee 3 is a master architect who has been instructing in the university for more than 18 years. Moreover, she has given lectures in ecologic structures course for three years. Her knowledge about green buildings and certification systems arise from her self-development and interest to the topic. *"Why are not all new renovation works examples of green building projects? I do not see why not. It is a prevalent property in new constructions but the number of existing buildings in Turkey is 4-5 times more than the new ones. That is why at least a part of the urban regeneration and other renovation works must be green. Their positive impact on the environment must be considered."* she says. It was a very good timing that the project met Interviewee 3 first when she opened the course about ecologic structures.

4.2.3. Resources

All construction works took nine months. Like in Case 1, Consulting Firm I was LEED consultant of the project. Consultants especially paid attention to water armatures in the building and guided the project team. Economic water faucets and reservoirs used in bathrooms were supplied from *Gröhe*. Besides, authorities from university performed tests on the building and it was determined that there was almost no need for improvement works for earthquake countermeasures. It was seen that structural elements of Building B were functional.

Architectural design of the project belongs to Interviewee 3. In design phase there appeared two options for the building: the first one was to keep the building's external view unchanged and extending the indoor area by demolishing old structural elements. The

second one was to stick to the history of the building and to renew it according to today's needs. The owners and the architecture of the project did not choose to break the original structure aiming of more construction area and gave preference to the second option.

Construction materials were procured from local suppliers. The outermost supplier was located in Adapazari where is only 170 km away from Istanbul. According to Interviewee 3, there was no difficulty in procuring environmental friendly materials for the construction. She said it was very easy to find such products in Turkey because they established a procurement plan before the construction began.

At the end of construction works, the project team calculated extra cost of greening the structure. It was found that green building concept caused 5% additional cost to the project. The main reasons for this extra cost are glasses used in windows and qualified labor force. Besides, adhesives and paint materials also brought some additional costs. Interviewee 3 takes it normally that in such a prestigious project there is some additional cost because of the materials used and qualified labor force. She adds that the choice of heat insulation glasses in windows was because of aiming for more LEED points.

4.2.4. Tools

Table 4.13. LEED scorecard summary of Building B.

LEED-NC 2009 Credits for Building B		
Categories	**Possible Points**	**Points Won**
Sustainable Sites	26	18
Water Efficiency	10	2
Energy and Atmosphere	35	12
Materials and Resources	14	6
Indoor Environmental Quality	15	8
Innovation in Operations	6	5
Regional Priority Credits	4	4
Total	**110**	**55**

- External walls of the hotel were coated with self-cleaning paint that repels dirt and grime. Self-cleaning paint is an environmental friendly product and keeps itself clean using daylight and nanotechnology. Therefore it is a maintenance free material. Besides, 53% of the materials used in the construction belonged to the original structure. Adhesives with low VOC amounts were preferred in the project.

- On more than half of the terrace roof, green roof application was implemented. Plants were chosen to be local, adaptive and less water demanding. Landscape of the terrace was so designed that it needs 65% less water when compared with other equivalent gardens. By this means, discharge on storm water system was reduced to two third of its capacity.

- EPA standards were considered during choice of water armatures. Reservoirs with 2.4 liters capacity are the most economic ones in their class because 4-6 liters capacities are accepted as normal.

- Power outlets inside the rooms were converted to controlled ones in order to prevent that they consume energy when they are in stand-by mode. New generation economic lamps were chosen in all lighting fittings in the hotel. Using chandeliers on the ceiling was abandoned during design phase.

- Windows are made of special wood and involve glasses with high heat insulation. During design phase, thickness of the glasses was increased. Indoor thermal comfort design was made according to ASHRAE 55 standard. In heating and lighting systems, 100% user controlled switches were preferred by the architect. Monitors were installed in the rooms in order to measure internal air quality.



Figure 4.14. (a) Windows. (b) Green roof. (c) Indoor details.

- As a result of computerized daylight modeling of the building, it was determined that 100% of the life places in the hotel receive daylight. Under favor of exterior design of the building, 97% of the hotel guests can see the outside from where they sit or lie. This was proven by calculations obtained via plans and cross sections of the building drawings.

- During construction phase, exterior sides of the building were covered with special texture in order to prevent dirt and dust from spreading out. This is not an ordinary implementation in any other constructions in Turkey. Moreover, existing storm water system was also protected from constructional rests.

- Although it did not bring any additional LEED points, all electrical household appliances were chosen from class A in energy efficiency. Their contribution to the environment was concerned.

4.2.5. Barriers

According to what Interviewee 3 said, there was no significant difficulty that the project team met during construction. However, the project team could not attend some points of LEED for New Construction and Major Renovations (version 2009) since Building B was a historic one and general structure of the building could not be changed.

4.2.6. Enablers

In Turkey, restoration works of historical buildings generally start after getting permission from *Council of Monuments* which is a governmental agency. It is very hard to get permission from this council and the process runs very slowly. It was an advantage of the project that there was no need for getting permission from the council, conversely the owners of Building B had to get restoration license from another governmental agency named KUDEB (Directorate for the Inspection of Conservation Implementations). It is fundamental duty of KUDEB to ensure that renewals of historical buildings are performed sticking to their original structures and no new adaptations are added. KUDEB which is an organizational unit of Istanbul Metropolitan Municipality works faster than Council of Monuments which is a unit of the ministry of culture and tourism, thus the project team did not lose extra time and got the permission to start working quickly.

Building B is a masonry structure from the 19th century. It was an advantage of cost and time that there was almost no need to reinforce the building before starting renewal works. Only cavities on main columns had to be repaired that were damaged in order to open extra windows in the past.

The subcontractor of the project did not complete any green building project before. However, its executives wanted to add a completed green building project to their portfolio hence the subcontractor company worked very hard during the process and was very helpful to the project team since they aimed to learn this very new concept.

Unlike other cases, during renovation of Building B the project team did not have any difficulties in procuring environmental friendly construction materials. It was enabled owing to *smart procurement planning*. This is a definition proposed by Interviewee 3 and she thinks that the procurement stage must be planned and a purchase policy must be established before construction phase. If it is preferred to look for suppliers during the construction phase, it is possible to lose time and to extend the project period. Since in this project all suppliers were determined and all necessary materials were found before the construction started, no time loss occurred due to any procurement problem.

From all items above and also what Interviewee 3 says, it can be said that a strong planning which was done during design phase enabled that the project team did not meet any difficulties during implementation stage.

4.2.7. Benefits at Project Level

There are only four flats in the building to rent for long periods and the owners of the hotel want to host well educated guests with environmental awareness. They believed that a green building certificate would provide that such guests could quickly prefer to stay in Building B when they look for a temporary flat in an environmental friendly building in Istanbul. When the customer profile as from 2011 is concerned, it can be easily seen that the owners attained their aim. Besides, with computer modeling, it was seen that 25% saving in energy consumption and 28% in water consumption were achieved.

Interviewee 3 says that: *"To raise a historical building by renovation is simply a true behavior and to crown the hotel with a green building certification is a truer behavior and the most important success of the project."*



Figure 4.15. (a) Rooms before LEED. (b) Stairs before and after LEED.

4.2.8. Benefits at Organization Level

According to Regulation for Energy Performance in Buildings which is stated in Turkish Energy Efficiency Law, all buildings in Turkey that have more than 50 m^2 construction area must have an *Energy Identity Card* at the very latest by the beginning of

the year 2017. According to this new system, all buildings will be classified in terms of energy efficiency with different classes between A and G. Buildings without an identity card will not be able to sold and bought. It is also expected that real estates with higher energy classes will have large economic advantages in both taxation and insurance costs. This will decrease the expenditures of the owners of Building B in the long run.

4.2.9. Lessons Learned

Procurement planning is one of the most crucial stages of the whole project process and must be formed before the construction starts. Suppliers should not be looked for during construction phase, on the contrary they must be found before implementation phase of the project. In Turkey, use of environmental friendly construction materials spreads increasingly and the number of their suppliers also increases.

Interviewee 3 supports a Turkish green building certification system which has equivalent rules to global standards. She finds working with an American certification system unnecessary. There are many inconsistencies in LEED when Turkish standards are considered. For example, distance perception in the USA is very different from that in Turkey since the USA is a continent country whereas Turkey is just as large as a state of America. This sometimes brings contradiction in evaluation. Suppliers within a radius of 500 miles (800 km) may be considered as local in the USA but in Turkey covering 800 kilometers is like passing across all the country. These contradictions show the necessity to create a Turkish green building certification system. Geographic conditions, climatic factors and cultural differences of each country must be considered in any country's own certification system.

The hardest stage of a conversion process of a building into a green one is to persuade its owners. In Turkey, people are afraid of possible investment costs of green buildings. However, they must be aware of the life cycle analysis of their buildings. Interviewee 3 mentions that architect and contractor can cooperate very successfully in a green building project only if the owners are determined to do it.

As a last word, Interviewee 3 calls attention to the environment: at least only for the environment some actions must be taken and green buildings are one of the most efficient ones. She adds: *"Mankind consumes in one day the amount of energy that has been stored on earth for 10,000 years. Let us not be afraid of the future, let us plan our future and do what is necessary."*

4.3. Case Study 3

4.3.1. General Information

Building C is a dormitory located in a public university in Istanbul. It is a men's residence building and a historical monument which was built in 1871. It is also the oldest building within the campus. It is a five-storey building and has 8,000 m^2 of construction area.

The university where Building C is found is one of the most prestigious educational institutions of Turkey. It has four faculties and two schools offering undergraduate degrees, six institutes offering graduate degrees and two service departments. More than 12,000 students study at the university and many of them come from cities out of Istanbul. University administrators decide to restore the dormitory and to get LEED certification in 2011 and chose Consulting Firm II as LEED consultant of the project during the whole conversion process.

Building C is the first campus building in Turkey that was certificated under LEED for New Construction and Major Renovations (version 2009) with 66 points in October 2012. It is the first campus building of Turkey that was awarded with LEED Gold certificate and the second oldest building in the world which was certified under LEED.

4.3.2. Drivers

It is stated in the university's vision that becoming green and sustainable is aimed and developing a green and sustainable campus is one of the tenets of its vision. It was also

set forth in the university's 2010-2014 strategic plan so that every new building which will be built in the future in any campus of the school should be a green one and application for LEED certification for each new building will be required. It is also mentioned that all campuses within the university will reach a net zero carbon footprint (or become carbon neutral) in the next years. It is planned to build wind power plants in a campus of the university and aimed to reach carbon neutral status by reducing carbon dioxide released into air from fossil fuels and also using renewable energy resources. Besides, all new buildings have to be environmental friendly, designed as barrier-free and their fire escape scenarios must be well planned. It is obvious that conversion of Building C into a green building and certify it under LEED is a proper attitude to the university's vision.

It is demanded by the university's administrators that if possible, reuse of grey water, installation of efficient armatures, constituting solar panels and putting recycle bins are requisite in all buildings. Since consumption rates in dormitory buildings are especially high, they are privileged in implementing green building applications. Building C was one of them and had to be renovated since it was a more than 100 year old residential building. Its cost of construction had to be provided by the university alumni hence a donation campaign was conducted to collect money to finance the renovation works of the dormitory. From statements of Interviewees 5, 6 and 7 it is understood that it was announced by the university management that Building C would be certificated under LEED in order to attract alumni's attentions and convince them to donate. It is clear that LEED certification was used as a motivation tool by university administrators.

4.3.3. Resources

It took one year to complete all construction works. The university hired a subcontractor for the whole architectural and civil works via its Directorate of Construction. The subcontractor company which is an experienced firm in renewal projects was chosen from the list of Ministry of Culture and Tourism. Besides, the Directorate organized a civil works team in charge of controlling the process. It was planned so that Consulting Firm II would help them document the necessary items in order to get the certificate. Commissioning report of the project was prepared by a third party.

The project was designed by a restorative architect. During design and planning stage, old photographs of Building C were found and design was made according to them. The renovated building was first modeled with a 3-D software program. When mechanical equipment, architectural, structural and isolation properties of the building and climatic conditions of where Building C is located were entered in the modeling program then the result was an idealized building of what was designed. The program calculated total gas and electricity consumption of the building within a year. Consulting Firm II found one of the best firms in building physics and energy modeling and that firm calculated the expected consumption rates of Building C according to that modeling.

When looked at expenses that were made during construction phase, it is seen that there was almost no expense in architectural adaptations on the contrary the main cost of the conversion project was due to change and renewal of mechanical installations. Glasses used in windows were changed with double glazing one year before the renovation and this brought points in LEED rating system. Interviewee 8 says: *"The main expense in converting to green is seen in mechanical installations and precautions taken in the construction site not to harm the environment. Apart from that, almost no extra expense occurs."* The cost of mechanical installations used in the project was 40% of the total project cost.

Since Building C belongs to a public university, the restoration project started with a small budget. As time passed by, needs of the project and also budget of the project were increased several times during the construction.

According to Interviewee 8, 80% of construction materials that LEED necessitates in green building projects can be found in Turkey. He says that mechanical systems are very improved in Turkey. Even if there is a system that cannot be found in the country, it comes very quickly from abroad. The project lost only 2 LEED points in materials and this shows that environmental friendly materials are easy to find. Interviewee 5 lists the materials that were hard to procure during the project: adhesives for wood without urea formaldehyde resin, carpets with *green label* and ceramic tiles with *floor score* certificate. When the project team could not procure these materials because they were very expensive

or unreachable in Turkey, then they used materials as functional as the ones aforementioned.

Interviewee 7 mentions that paint materials used in Building C were expensive but they have met the requirements: the paints were water based, with low VOC content and without any chemical solvent. The same requirements were also met in adhesives. Wooden material suppliers with FSC license were preferred. A wooden material with FSC license means that the product's raw material was obtained from a forest that was managed well according to environment consciousness and the product was fabricated according to this also. All the wooden materials used in the renewal project of Building C had FSC license. Interviewee 6 says *"When the building constructed as green, then the client chooses leading companies as supplier."* and shows the importance of supplying firms in a green building project because only leading companies can set research and development budgets. Owing to their research and development works, leading companies can meet the expected requirements of green building projects.

Wooden materials of the project were supplied from European side of Istanbul where Building C is also located, hence they were considered as local materials. Aluminum and steel materials were produced from recycled resources. As flooring material, linoleum was chosen instead of PVC. This choice was beneficial since it was an organic construction material. Price of linoleum per square meter is more expensive than PVC by only a few Euros and the project got high scores from LEED on that matter.

The R value of the masonry stones was measured. The thickness of stones was 70 cm. The tests, conducted by *Testo,* showed that heat loss was minimal. The R value is a measure of thermal resistance used in construction sector. During the tests, internal temperature was raised to 30°C in order to create a 20°C difference with the outside temperature. The test results pointed to a heat loss that was far below standards. During finishing works it was noticed that the first builders left a wooden frame structure and an air space between stones in order to provide better heat isolation. Because of that there was no need for adding new radiators to Building C. It was decided so that the existing radiators' number and locations would stay unchanged. Ninety percent of its load bearing

elements and 75% of non-load bearing elements were kept without any change. As it can be seen from the aforementioned examples, the structure enabled that the project team could implement all energy efficient tools easily.

4.3.4. Tools

Table 4.14. LEED scorecard summary of Building C.

LEED-NC 2009 Credits for Building C		
Categories	**Possible Points**	**Points Won**
Sustainable Sites	26	19
Water Efficiency	10	10
Energy and Atmosphere	35	17
Materials and Resources	14	6
Indoor Environmental Quality	15	7
Innovation in Operations	6	3
Regional Priority Credits	4	4
Total	**110**	**66**

- Smoking is forbidden in each floor of the building. People can smoke at a minimum distance of 7.5 m far from the building.

- To encourage bikers, two bicycle parks were built, one of them is open and the other one is roofed and 5% of the capacity of the car park was reserved for low emitting and fuel efficient vehicles only.

- According to proven results taken from the measures of a light meter, 75% of life spaces in the building receive daylight with an intensity of at least 110 Lux and economic lamps were used in lighting installations. Besides, doors and glasses are proper to heat isolation.

- It was projected that a dormitory with a population of 218 students would produce about 600 kg of waste material. It was estimated that 275 kg of it would be

recyclable. So recycle bins were placed in every floor. The total number of the bins is 30 in the building.



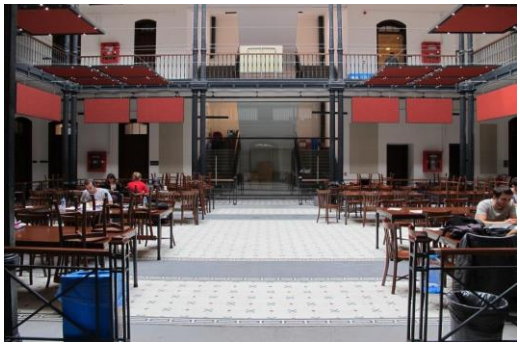

Figure 4.16. (a) Recycle bins on the floors. (b) Renewed study hall.

- Local materials were chosen to be used during construction. All paint and adhesive materials had low VOC contents which were in compliance with *Green Seal* standard.

- The ventilation systems in the cafeterias within the building were so designed that the warm air coming through exhaust hoods are firstly filtered and then brought into contact with fresh air pipes. This enables heat transfer and that fresh air is heated from 4°C-5°C until 12°C -15°C. Then the heated air is warmed up with serpentine to 24°C-25°C and blown into the building's indoor life spaces. By this way, cost of heating was reduced and work load of the boiler decreased. Since the boiler was not replaced by a newer one during the construction works, it was necessary to decrease its work load. Solar hot water system panels were placed on the roof in order to absorb sunlight and to gain heat energy. They met 0.78% of total energy consumption of Building C and this obtained energy reduced the amount of heat energy that the boiler must supply. Besides, it was decided not to install any cooling installation in the building.

- In heating and lighting systems, user controlled switches were implemented in all rooms of the building. Sub-metering devices both in energy and water consumption were placed in order to follow consumption rates.

- Sound isolation of all clubs and social activity rooms were completed so that students could work properly in the study. Rock wools were used between plaster walls in order to provide better isolation.

- Fire sprinkler system which is an active fire protection measure was installed in the building. Fire escape stairs that had been added to the building in the last years were removed and original fire escape doors were reopened again.

- During construction, all rubbish was transferred out of Building C through corrugated pipes which prevent dust from spreading on. All the rubbish and debris were bagged in order to be transferred without harming the environment. Outside laying construction materials like sand were covered with a large piece of cloth. By this means, the materials did not foul the outer environment when it rained. Storm water system was protected from constructional rests during implementation of the project by covering them with geo-textiles. Tires of the trucks working on the construction site were washed in a basin every time before they went out of the site. Besides, waste materials arose during the construction works like clay, firebricks, PVC, glass, paper, wood and steel were sent to recycling. At the end of the construction period, the building was ventilated by opening all windows and letting all the contaminating materials fly away. Then an internal air test was conducted in compliance with *EPA Compendium of Methods for the Determination of Air Pollutants in Indoor Air EPA/600/4-90/010* standard. The results are as the following:

Table 4.15. Internal air test results.

Contaminant	Max. Concentration
Formaldehyde	50 ppb
Particulates	50 µg per m³
Total VOC	500 µg per m³
4-Phenylcyclohexene	6.5 µg per m³
Carbon Monoxide	9 ppm but not greater than 2 ppm above outdoor level

- Grey water recycling system was set up in the building, by this way waste water from bathing or washing can be recycled and reused in reservoirs. Aerators which save water by limiting the total flow of water were used in all taps, shower faucets and sinks. In Turkey, average flow rate of shower faucets is 24 l/minute. An economic shower faucet's flow rate is 12-15 l/minute whereas flow rate of the shower faucets used in this project is 10 l/minute. Lavatory faucets in Building C have a flow rate of 3 l/minute, urinals have a capacity of 3 l/use and reservoirs have a capacity of 2 or 4 liters per use.

- A ventilator was placed in darkroom inside the photography club's room. The ventilator creates a negative pressure and so ventilates the air. Such a device is strongly recommended by LEED because in a darkroom chemicals are mixed up in the air when used and this is bad for health.

- Last and the most important innovation in Building C was that the atrium in the middle of the building was returned to its original shape: when the building was first built, there was a quadrilateral atrium without any roof on its top located exactly in the middle of the structure. In the past years, the top of the atrium was roofed and mezzanines were added to the building. Then the bottom floor of the atrium was formed into a study hall. Via this renovation project, mezzanines and roof of the atrium were demolished. The top was covered with a glass window, by this way ventilation and lightening requirements of the study hall were satisfied. Natural ventilation was provided. Besides, automatic windows and carbon dioxide detectors were placed on the roof. When fresh air decreases in the study, these windows are opened automatically and provide ventilation.



Figure 4.17. (a) Atrium before renovation. (b) Atrium after renovation.

4.3.5. Barriers

The biggest difficulty which was encountered during the project was that Building C had to be opened in September 2011 before having finished construction works since school year 2011-2012 had already started. Construction period took longer than expected. Labor kept on working on the study hall which was surrounded with wooden walls while some students were living in the dormitory and some of them were continuing their social activities in student clubs rooms.

Since consumption rates of Building C were not recorded in the past years, it was impossible to calculate the savings owing to the green building implementations. It was because all consumption rates of the university were recorded in a lump sum account.

In the design of the project, showers for both men and women should exist in the building in order to get LEED points. However, since Building C is a men's residence, it was impossible to have showers for girls in the building.

Grasses are not proper plants for an economic landscape since they consume 10 liters water on each square meter. There are many areas covered with grass near Building C, Consulting Firm II offered clovers which consume less water to be planted instead of grasses but offer was declined by the university administration.

When the project specifications were first prepared, it was not indicated that the building had to fulfill LEED requirements. The contractor and the subcontractors started to work without knowing any LEED principles. They were later ordered to work according to LEED standards hence there were difficulties during preparing documentations needed for LEED certificate. This caused that the contractor and subcontractors not to be able to supply necessary documents demanded from them like ESC plan, recycle plan of the wastes, content reports of the materials used etc. They were unaware of these concepts. They resisted to what project team demanded from them because they did not want to lose any time by preparing documents instead of keeping on constructing.

At the very beginning of the project, the project team was strange to LEED, ASHRAE or any other foreign standards. Consulting Firm II was supposed to help them prepare necessary documents in English. However, the project team had difficulties because of variations in consultancy team. Since it is hard to find qualified employees who have wide knowledge in LEED procedures and principles, consulting firm had several times difficulties in supplying personnel for the project. Besides, it was also difficult to find an expert who could write a commissioning report of the project.

Documentation of the project took very long time. It was finished nine months after the project was completed. This led to that Building C was certified under LEED one year after the construction works were done.

Since the project belonged to a public university, budgetary constraints were put several times by the university. Administration of the university made tiny distinctions during the project because each project within a public institute is investigated at least once in a year by officials of Supreme Court of Public Accounts.

R values of the stones used in original masonry structure were unknown. The project team of the university delegated conducting R value tests to Consulting Firm II. The consultant team conducted the tests via their contacts in the technical university and this process took exactly two months which was very long and tiring for such a simple test.

According to LEED standards, natural ventilation holes must be at a distance of maximum 7.5 meters from where people are. If the holes are at a longer distance, then LEED requests CFD report of indoor places. Since glass roof of the atrium is found at a much higher distance than 7.5 meters, CFD report of the atrium had to be prepared. The project team of the university had no time for these assignments because the documentation process started after the construction works were completed. They had to attend to other construction projects going on within campuses. So the consultant team asked a professor of thermodynamics to prepare the CFD report of the atrium. Completing this report took three months.

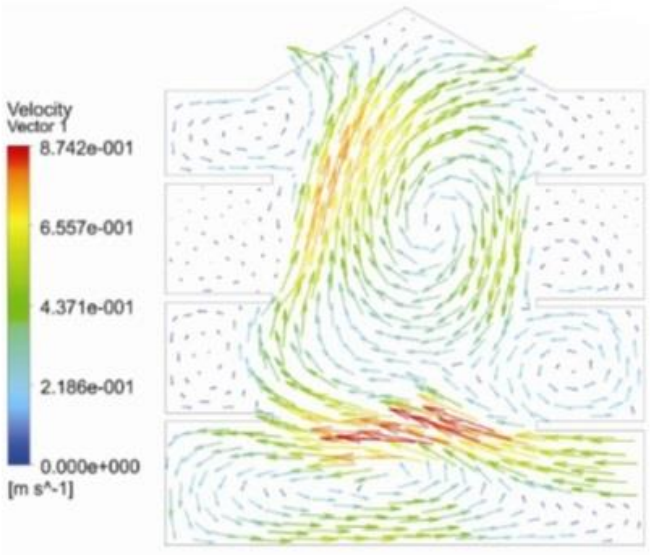

Figure 4.18. CFD model of the atrium.

Since Building C is a heritage building, nothing except for cleaning works could be done on the external walls of the residence. It was impossible to implement a white covered roof and shading windows or to place photovoltaic panels so LEED points could not be gained in these requirements. They were handicaps of a historical building that was tried to be certified under LEED. Besides, there is no basement floor of the building hence it was very hard for design team to place electric and mechanical rooms in the building.

It was an architectural difficulty that there were many different facilities in the dormitory. In the building there are residence rooms, social activity rooms, a canteen, stationary and other small shops. There were so many different criteria that the project team had to fulfill like ventilating warm air from the canteen and other small cafes, making sound isolation of social activity rooms, providing a comfortable environment for resident students etc. They were difficult to be provided at the same time. Additionally, design had to be changed several times due to change in type of shops on the bottom floor of Building C. At the very beginning, neither canteen nor café was stipulated in the building but later the university administration decided to open them. This caused that all the mechanical projects had to be redesigned from scratch.

According to Interviewees 5, 6 and 7, Turkish people are still unaware of green building concept. They give a sensational example: when they first said to the architect who had to draw the projects that the building would be green, the architect asked if the dormitory would be painted with green. Likewise they were also strange to the new concept and had to work hard to learn new things. Interviewee 5 admits that he had no idea about what CFC gases were. They are a group of organic compounds which destroy ozone and reduce its layer's thickness and used in refrigeration and air conditioning. Since the contractor was also strange to LEED, its project team could not supply demanded documents like photographs of the construction site, dispatch lists, materials' content reports etc. All these works were mainly pushed off on the consulting firm's project team.

Some suppliers were fulfilling BREEAM criteria although their materials were not proper to LEED requirements hence it was hard to find suppliers for working together.

Interviewees draw attention to importance of building management. They say: "*All the facilities within Building C use the newest technology and are considered state of the art. However, it is also important to manage it in the correct way.*" For example, grey water tank should be cleaned twice a day and the project team is afraid of that it may not be performed properly.

4.3.6. Enablers

The project team of Directorate of Construction Works of the university was not well informed about green buildings at the beginning of the project. However, they devoted themselves completely to conversion of Building C into a green building and improved themselves. When they had difficulties, consultant team helped them overcome the difficulties especially during documentation stage.

The team of Consulting Firm II went over hundreds of drawings and documents of the project and made them suitable for LEED documentation process. For example, some important points on the design drawings had to be highlighted, all documents had to be translated into English, some notes had to be added on etc. All of this work was performed by the consultant team and they eased the project team's work. Besides, they visited the construction site regularly in order to get information directly from the field.

A very comprehensive cost benefit analysis was performed before choosing the energy efficient tools that would be implemented in the project. The project team chose investments with shorter payback periods. As a matter of fact, LEED does not recommend any investment without perceptible paybacks so it was another reason why the project team made tiny distinctions about this issue.

There was an important success factor within this project: the project coordinator who was appointed by the university administration. She was university's representative within the project and also held a mediatory position between all the parties. On the one hand she calmed down the students who could not make use of the study hall for a long time on the other hand she pressured the contractor into finishing the construction as soon as possible. She also motivated the project team successfully during the compelling process. Her management skill was no doubt one of the critical success factors.

Building C had its own advantages that brought some LEED points. For example, the building is located in a central area of Istanbul and there are many bus lines passing just in front of the campus. These brought points in sustainable site criterion. Besides, its atrium and masonry stones with very low R values helped the project team green the building.

4.3.7. Benefits at Project Level

Since thousands of students make use of the study hall every day and they convey complaints or appreciations to the university administration without any hesitation, it is known that there are no complaints about decreased flow rates of taps and shower faucets in the dormitory. Students who work in the study are glad of that there is now effective sound isolation in social activity rooms, lightening of the study hall is much better than before, ventilations of canteens function properly and no smell of grill or furnace infiltrates the study, residents are more satisfied because of increased comfort in the rooms and students who use social activity rooms are also pleased with renewed rooms.

The recycled water that comes from grey water system was analyzed and it was determined that it could even be used to wash hands. However, it is only used in reservoirs and garden irrigation system.

After renewal works were completed, it was calculated that the amount of saved water per year is 3800 tons which is 67% of total amount of water consumed in a year according to Turkish Standards. There is a daily saving of 46 tons of fresh water. In Figure 4.28. comparison with EPA standards can be seen. These values were calculated by multiplying estimated number of users, their usage frequency, usage period and unit consumption rates of the equipment that were used in Building C. On the other hand, yearly amount of black water was reduced 48% according to TS and 30% according to EPA.

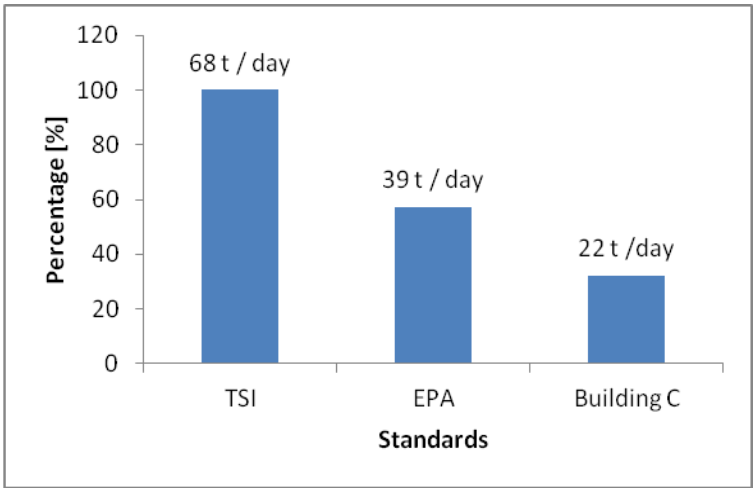

Figure 4.19. Comparison of daily water use according to different standards.

Last but not least, according to energy modeling which was performed according to ASHRAE 90.1-2007 Standard, it was seen that there is 26% of saving in energy consumption in the building. With current energy prices, it means a saving of 12,000 $ per year.

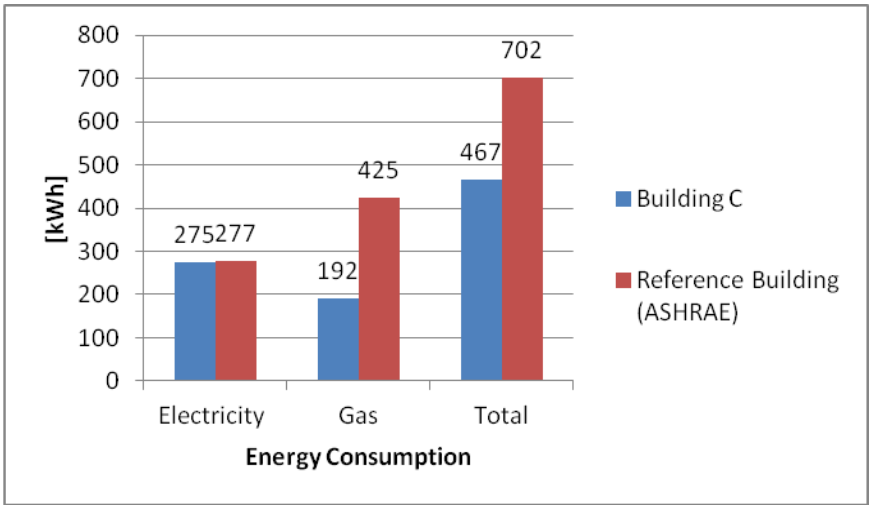

Figure 4.20. Comparison of daily energy consumption.

4.3.8. Benefits at Organization Level

Greening Building C is a completely correct strategy for the university. It shows the truthfulness of what was written in the university's vision. The news of the project appeared in national press. It was also advertised in the Second International Summit of Green Buildings in Istanbul.

The university keeps on erecting green buildings: there is another conversion project of an old factory which belongs to the university. When the project will start, it will be aimed to certify this building under LEED. There is also another ongoing project which will be certified under LEED and it will be a high technology building. Personnel of directorate of construction of the university gained wide experience in making green buildings and working with LEED standards. They also became registered LEED architects and mechanical engineer. These issues will help them complete other green building projects in the future.

4.3.9. Lessons Learned

Although the project coordinator did her best, there was a certain lack of project management during the process, especially in technical issues. This is the main reason why the certificate was received almost one year after the construction was complete. Coordination between the project and consultant teams is crucial.

It was a major mistake of the university administration that it was not indicated in the project specification that the renovation would be carried out according to LEED standards. This caused difficulty in getting necessary documents from the contractor and subcontractors because they were not ready for LEED criteria. Since the project was standardized according to LEED after the specification was published, there were also hidden costs occurred for the contractor company later. When next time preparing a green building project, the university has to clearly highlight the standards that contractors firms must conform to.

According to Interviewees 5, 6 and 7, the first budget of the project was not sufficient for such a green building conversion project. The government is inexperienced in green building implementations hence executive organs of the government must work on this issue.

Management of a green building is as crucial as its conversion. The personnel working in a green building must be well trained and the building must be managed according to certain rules. Otherwise energy efficient tools implemented become useless.

The project team offers that plaques or boards can be hung on the walls of Building C so that they refer to energy efficient tools implemented in the project and savings achieved. By this way environmental awareness of the students may be increased. The team also supports a Turkish green building performance assessment system. If this will not be possible in short term, they are on BREEAM's side when compared to LEED. Since BREEAM is a European organization, it is closer to Turkish Standards than LEED which is American.

The structure of the building was very helpful to the project team. Its highly isolated masonry walls, the atrium in the middle of the dormitory and its double glazed windows which were placed one year before the renovation caused that the project gained some LEED points easily.

Locating canteens in Building C was a hard decision for the university administration since it was very difficult to generate solutions for this issue both in planning and implementation stage. There were especially problems in mechanical projects. According to the project team, canteens had to be gathered in another building of the campus like in other universities in Istanbul.

As a last word, Interviewee 7 says: "*Every building must be green even if they are not certified. A green building saves up to 40-50% of water and energy consumptions. I certainly recommend green buildings*."

4.4. Case Study 4

4.4.1. General Information

Building D belongs to a firm which is a research company conducting nationwide surveys in political, sporting, educational and marketing issues. The company was founded in 1998. There are almost 45 employees working in the building. Building D was built in 1991 and is the main office building of the company. It has a total of 1950 m^2 construction area and 460 m^2 land area.

In order to convert Building D to a green building and certify it under LEED, construction works started in July and finished in November 2011. It was certified under LEED for New Construction and Major Renovations (version 2009) with 69 points in 2012. It is the first renovation project in Turkey which gained LEED Gold certification.

4.4.2. Drivers

The company has a strict environmental responsibility policy. General manager and Interviewee 9 who is administrative affairs manager of the firm are members of TURCEK which works for preventing marine, air, soil pollutions and also for protecting natural life. Due to their environmental awareness, company employees plant tens of trees in every April in Istanbul. Each employee in the company has at least one planted tree.

The company sends to its clients planted tree certifications of TEMA as promotional items. Besides, there is a memorial forest in front of the company which was planted by its employees.

There was also another factor which led the company executives to decide to green their central office: owners of the company and Consulting Firm III are old friends. At a business dinner in 2011, they spoke of Building D which was about to be renovated those days. Since the owner of Consulting Firm III is versed in green building constructions and certification systems, he managed to convince the owner of the research company to

perform renovation of Building D according to LEED standards and then to apply for a certification.

4.4.3. Resources

When looked at expenses of the project at the end of all construction and documentation works, it is seen that the major cost of the project belongs to LEED consultancy service. Since this was a renovation project, there were certain expenses to be made independent from being green. According to Interviewee 10, the only expense made for LEED was waterless urinals.

Interviewee 10, the architect of the project, was the only decision maker of the project since the owner of the company gave him a free hand. He determined the concept of the project with the owner and performed management and procurement of the construction. He is also experienced in being a contractor apart from his advanced architectural career. Green building implementation is in his field of interest. In time, he improved himself in this issue, especially in economic aspect of these applications. He has acquired wide market intelligence. By this means, he managed to get low prices for such implementations during the project. His and his construction team's working principles and green building concept suit well. For this reason, they implemented green building energy efficient tools in renovation project of Building D easily. They are used to construction applications in green buildings different from other ordinary construction implementations.

Owing to Interviewee 10's strong architectural perspective, in the renewal project great importance was given to heat isolation, water and energy savings, removing natural gas installations and improving indoor comfort. Independent from aiming of LEED certification, these applications were designed for the project. Well-known brands were chosen as solution partners. In office furniture and equipment, products were chosen so that they are made of environmental friendly materials. Interviewee 10 stayed out of cheap materials with high VOC contents. Floors were covered with laminated parquet which is cheap and easy to use. The cost of laminated parquets in the whole building was about 25,000 TL. Conventional parquets were not used because of their short economic lives.

The architect did not choose granite as flooring material since it emits radiation and also not marble because it creates significant extra loads for the building.

Interviewee 10 says: "*Architecture is four dimensional which means that an architect must consider the life span of his/her product. A building must remain standing for long years.*" He gives Building D approximately 20 years to stand. According to his opinion, office buildings' expenses increase with each passing year. He thinks that after completing its economic life, it will be demolished and rebuilt.

4.4.4. Tools

Table 4.16. LEED scorecard summary of Building D.

LEED-NC 2009 Credits for Building D		
Categories	**Possible Points**	**Points Won**
Sustainable Sites	26	21
Water Efficiency	10	9
Energy and Atmosphere	35	13
Materials and Resources	14	5
Indoor Environmental Quality	15	13
Innovation in Operations	6	4
Regional Priority Credits	4	4
Total	**110**	**69**

- Interviewee 10, architect of the project, removed natural gas installation from the building. Acclimatization was provided with air conditioners. Kitchen tools like furnace and oven in the building run on electricity. He made such a decision because electricity can be generated from renewable energy resources like wind or geothermal energy whereas gas is an example of fossil fuels which will run short one day. Besides, in heating and cooling, electricity is used more efficiently when compared to gas. With electricity, a COP of 4.3 is achieved in heating and a COP of 4.1 in cooling. However, with natural gas a maximum COP of only 1.4 is possible. In cooling and heating system within Building D, VRV3 system was used. COP is the ratio of heating or cooling provided over the electric energy consumed.

COP of this VRV system is 4.03 whereas local air conditioners have an average COP of 2.2. Besides, there are carbon dioxide detectors both in some rooms and garage which activate the ventilation system when needed. CFC gases were not used in air conditioning system, instead of this ozone friendly R410 gas was chosen. Air conditioners in the building need 25-30% fresh air to function. In order to run the air conditioners in inner rooms properly, plastic pipes were installed between the devices and exterior sides.

- In wet areas sensor faucets with low flow rates, waterless urinals and reservoirs with only a capacity of 5 liters were chosen. However, not every faucet was chosen with sensor. The architect explains his choice: *"Sensor faucets may cause uneasiness for some users. I did not want them to be uncomfortable since guests of the building are usually from prestigious companies. Hence I made such an architectural decision."* There is a small water treatment plant in the building and it supplies such clean water that it can be reused. However, the reason for choosing a water treatment system is to reduce use of cleaning chemicals such as detergents, soaps, washing liquids and shampoos. Besides, there is a potable water filtration system in one faucet and its filter is changed every other month.

- Local plants were chosen in landscaping in order to save water. The landscape project was designed so that there was 86% water saving when compared to its equivalents. Total green space of the project covers only 30 m^2 of land and it is hardly ever irrigated. So it was not chosen to implement a large rainwater store reservoir in the project however there is only a small rainwater storage which is used in reservoirs in the toilets.

- Local suppliers were chosen during the project and even the new furniture was made of health friendly materials. Twenty percent of the total project cost was paid to local suppliers.

- Ninety percent of life spaces in Building D receive daylight with an intensity of minimum 250 Lux and this brought LEED points. In addition to this, 92% of life

spaces in the building have an outside view. In the project it was aimed to exploit the daylight. Wall lamps are turned on and off with switches enabling dim control whereas LED lamps on the ceiling work with light sensors. Besides, on each employee's table there are lamps with dim control.

- There is a space of 2 cm width between double glazed windows including argon gas and this provides low thermal conductivity. U value is the inverse of R value and the windows in Building D have a U value of only 1.1 which is the minimum amount existing in the market. They are also ultraviolet resistant. There is an automatic solar shading system consisting of curtains on front side of Building D. Its aim is to prevent sunlight from increasing temperature in the building especially in the mornings.



Figure 4.21. (a) Façade of Building D. (b) Meeting room after LEED.

- During construction works an ESC plan was applied and trucks' wheels were washed each time they leave the site.

- Parking garage is on the basement floor thus heat island effect was prevented and some LEED points were gained.

- Besides, a movie room was built in the building in order to increase employees' motivation through collective social activities.

4.4.5. Barriers

It was very hard to get material content reports from suppliers or subcontractors. Many of them are still unaware of environmental friendly products or green building concept. In spite of the fact that local suppliers were chosen in the project, there were certain foreign suppliers especially in paint, air conditioning system and electronic infrastructure since Turkish suppliers could not meet technical requirements in these areas.

The subcontractor responsible for technical infrastructure works could not provide full automation in Building D although in project specifications it was mentioned. According to what Interviewee 10 says, the only automation they could provide in the building is lamps working with sensors. Apart from that they could not manage to set up a control room and automate the heating and cooling, general lightening and ventilating systems although all the automation project drawings were prepared. The subcontractor was inadequate in implementation. Even if it was possible to provide full automation of the systems with tablet technology which had a total cost of 5,000 TL, the subcontractor failed in achieving a solution. Besides, LED lamps attached to stretched ceilings could not be fastened up well because of poor workmanship hence some of them could not hold on to the ceilings and fell leading to an unaesthetic appearance.

During construction works of the project, the company made an application for EFQM Excellence Model that is a tool to help organizations establish appropriate management systems. In order to let KALDER visit the office building and control the company in the context of meeting EFQM requirements, the construction had to be completed quickly and this made the project team hurry. During such a busy schedule, Interviewee 10 had to handle single-handedly all of parties such as the owner, consulting firm, suppliers and the project team.

During documentation process, all the measurements had to be converted to American units such as feet or miles. According to Interviewee 10, this was a kind of time loss although it was not a significant effort. He also thinks that people are still not ready to use green building applications in Turkey. He says: "*Even the contractors are unfamiliar with green buildings then how can we expect from the users to be? If users leave the taps open when they get out of the toilet then it does not make any sense to implement energy efficient tools in buildings.*" Interviewee 10 does not find understanding of engineering in Turkey sufficient and gives an example from the project of Building D: the maximum power that the systems within the building need when all of them work in full capacity is 48 kW however a generator of 120 kW was procured for the building. According to Interviewee 10, this shows the tendency for staying on safe side instead of optimization.

4.4.6. Enablers

Consulting Firm III was very helpful during documentation and certification processes and also lent assistance in choosing proper suppliers. The project team of the company was led by Interviewee 10 and the owner of the company who is a civil engineer. They made important decisions together with consultancy team and acted in concert. Interviewee 10 took the whole initiative in construction works and completed the project in five months.

Because of the company's ecological approach, the project team gave importance to efficient use of the sources. They did not invest in tools that have longer or no payback periods, as a matter of fact that would be an inappropriate action for LEED principles. Energy efficient tools to be implemented in Building D were chosen regarding needs of only 45-50 people. Unnecessary improvements were avoided. For example: a waste water treatment system of 15,000 Euro was at the project team's agenda but it was abandoned later since the office building did not need such a complete facility.

Today's technology enables implanting of about 50 meters long pipes in ventilating installations. By this means, the whole building could be acclimatized with air conditioners. In the project, chiller systems were not used although they have an average

COP of 5.5 because their cost-benefit analysis resulted in high values. Maintenance of chiller at temperatures of 23°C -25°C needs extra energy consumption that is expensive and unfeasible when there is no stream or sea in the vicinity. Interviewee 10 says: "*VRV is the most appropriate heating and cooling system for such medium scaled projects.*"

In procurement stage, suppliers were chosen that provided both technical solutions and analysis. Especially foreign firms are very good at providing content reports of their products or materials whereas Turkish ones have difficulties in this issue. Interviewee 10 adds that foreign firms in such projects give better prices than Turkish suppliers contrary to common belief. Another point is that there is no extra cost of procurement process in green building applications since they are already premium projects and require qualified products and materials. Among the project suppliers, supplier of aluminum joinery provided demanded reports easily and quickly. Its technical assistance was crucial for LEED certification stage since façade works included 15% of the total project cost. Besides, Mitsubishi proved that its product was produced from recycled material hence appropriate for LEED criteria.

Since total building area was not large, there were some difficulties that the project team had to solve. One of them was that sewage drain on the ground floor had a slope that was less than 1%. To provide that toilet wastes flow easily, the project team decided to use a motor pump on the ground floor. However, it was still hard to solve the problem since there were many pipe elbows in the mechanical installations. At this point, solutions offered by a foreign composite pipe supplier helped the project team handle this problem.

4.4.7. Benefits at Project Level

In Building D fresh air was supplied 30% more than what is stated in ASHRAE standards. Additionally there is 23% saving from energy consumption and 40% in water use.

After the renewal works finished, employees moved in Building D from their old office building. Heating expense of the company decreased when compared with the past. Heating cost per person was also reduced.

The exterior side of the building was mainly covered with glass so that the building is almost transparent. The floors were designed as open plan office. These properties provide a better work environment and employees enjoy it. Since the firm is a research company, they conducted quickly an employee satisfaction survey in Building D and determined that there is an increase in employee satisfaction.

4.4.8. Benefits at Organization Level

The company has now a building certified under LEED. According to Interviewee 9, greening their office building was an appropriate choice for their company since it is in the company's mission to act in accordance with their environmental responsibility.

Because the company works with worldwide known firms in Turkey, its prestige is also important. Interviewees 9 and 10 believe that image and public opinion are crucial in service industry so it was a correct decision to get LEED certification. They think that they became successful in such imponderable concepts.

Expenses of the office building decreased in terms of energy consumption, water use and consumables. Finally, the company was awarded in Second International Summit of Green Buildings that was organized by CEDBIK.





Figure 4.22. (a) Waiting room of the office. (b) Entrance hall of Building D.

4.4.9. Lessons Learned

It was a failure of the project that full automation of ventilating, heating and electronic systems within the building could not be provided. Choice of subcontractor firms is crucial as it can be seen in this example. Interviewee 10 mentions: "*In spite of missing automation, electric bill was only 8,000 TL. I believe it could be 7,000 TL with full automation of the systems.*"

According to Interviewee 9, the company will continue performing its environmental responsibility tasks. He believes that they make right by behaving responsibly although there are many imponderable concepts.

Last word belongs to the project architect: "*The largest share in Turkey's importation amount belongs to energy. Energy is so precious for our country since we cannot generate sufficient amount of it with national resources. For this reason we must not waste energy under any circumstances. Green buildings may be a start for a solution*."

4.5. Case 5

4.5.1. General Information

Contractor of Building E which is a member of TCA was founded in 1959 and completed many construction projects of power plants, factories, oil refineries, metro systems, pipelines etc. The company continuously takes place in *ENR Top 225 International Contractors* list.

Administrative and engineering units of the company in Ankara were in different areas of the city and company executives decided to gather them all in one headquarters building. In March 2010 the company purchased a building which was built in 2006. It was a *core and shell* building so it had only structural elements. Then the project team shaped the building in accordance with the company's requirements and equipped the building with electromechanical systems of latest technology. In August 2010 all employees of the

company in Ankara moved in this building and used it as corporate headquarters six months long. Then executives decided to apply for a LEED certification and the application was made in October 2011. Finally, in November 2012, Building E which is the headquarters of the company was certified under LEED for Existing Buildings: Operations and Maintenance with 71 points becoming the first building with gold certificate in LEED existing buildings category. The building has a total of 20,000 m^2 construction area and there are 380 employees working there. Consulting Firm IV performed service of LEED consultancy during the process.

4.5.2. Drivers

In 2011, some engineers of the company and guests who visited the building several times suggested that the headquarters building could be certified under LEED since it was equipped with electromechanical systems that help the building save water and energy and also provide a favorable work environment. Executives of the company considered this suggestion and decided to apply for LEED certification. They were convinced that the headquarters building needed almost no additional modification or construction work to be certified under LEED.

Interviewee 11 explains why they decided to have a green headquarters building: "*Our company is a firm doing business in energy sector. We believe a company in energy sector should have an office building that does not harm the nature, pollute the environment less and provides an atmosphere where employee satisfaction is high*."

4.5.3. Resources

Just before the application for LEED, the headquarters building had been installed with the latest equipment and systems. The company had invested much in its new headquarters building. When it was decided to be prepared for a certificate application, it was seen that there was almost no need to change anything. Only 15,000 $ was spent during certification process. Minor changes were made in building management methods in order to raise environmental awareness among the employees and to find solutions

leading to an efficient operating. When the project team started to prepare for LEED certification, energy modeling of the building was made first. Since metering systems were equipped in all installations, modeled values were compared with actual consumption rates. It was determined that there were some high consumption rates in several expense items which had to be reduced.

The project team of certification process consisted of experts from different fields. The project leader was Interviewee 11 who is an electronic engineer and also technical manager of the headquarters building. Other team members were corporate communications director, corporate communications manager, quality assurance manager and his assistant. They worked together one year long during implementation and documentation stages. Interviewee 12 is an electrician and he was also in the project team. He was also controller of the company during installation and construction works after the company first purchased the building. Since the company owns ISO 14001 certificate, their employees were relatively experienced in procuring sustainable consumables and some other green building applications.

Consulting Firm IV performed thermal measurements and determined efficiency rates of installation elements. According to the results, some improvements were made in the headquarters building. On the one hand these improvements and settings took only one month and on the other hand application and documentation process took almost one year. "*There are hundreds of photos and records that have to be prepared hence one year is an expected time period. We had to explain to LEED contents of toilet papers and hand soaps, to where wastes are taken away and also parking area of disabled guests*." says Interviewee 11.

Cost benefit analysis was performed when making decision on energy efficient tools in the building. For instance, the project team wanted to take advantage of cold weather of summer nights in Ankara by cooling chillers with this air at night when they do not work. Cooling chillers at nights would reduce the amount of required energy but this investment would cost about 250,000 Euros and the system would pay for itself in six years. However the company executives did not decide to implement the system. One

another example was that offer of implementing solar panels in the headquarters building was also refused by the administration since their payback period was more than six years.

4.5.4. Tools

Table 4.17. LEED scorecard summary of Building E.

LEED-EB 2009 Credits for Building E		
Categories	**Possible Points**	**Points Won**
Sustainable Sites	26	15
Water Efficiency	10	9
Energy and Atmosphere	35	23
Materials and Resources	14	7
Indoor Environmental Quality	15	9
Innovation in Operations	6	4
Regional Priority Credits	4	4
Total	**110**	**71**

- The company established a green purchasing policy for consumables including even toilet papers and fluorescent bulbs.

- There is a strict waste management within the building. Besides, domestic wastes are collected by a registered firm.

- City water is first treated in a treatment system before it is consumed. Besides, there are four different panels of fire extinguishing systems.

- The hourly maximum power that the headquarters building needs in summer days is approximately 700 kW. There are two main generators of 600 kW power, leading to a total power capacity of 1200 kW. When electricity goes off, they work in a synchronized manner together.

- A preventing maintenance plan for all installation systems and devices was established by the project team. Periodic maintenance sheets of all devices are followed regularly. There are two chillers, 450 FCUs, six main air conditioning unit, three boilers, two generators and many pumps in the building. The project team moved with the motto *"The best reparation is the maintenance."* and aimed to prevent possible breakdowns before they occur. A breakdown of any system even for some minutes could be very costly.

- Since the building is covered with glass, it was seen that indoor temperature in summer increased until 60°C several times. In order to prevent this, filter layers that does not transmit ultraviolet lights were placed in the glasses. So less amount of energy is needed to cool the whole building.

- Some chemical products were added to fluids that are used in cooling systems. These additives provide that pumps work more efficiently and also their life time is increased.

- Intensity of the whole lighting system within the building was reduced by 15%. Human eye could not distinguish such a small difference. Before this adjustment, some measurements were made and the average light intensity was found as 750-800 Lux that was higher than generally accepted standard of 500 Lux. After adjustment, it was measured again and seen that average light intensity dropped to 450-500 Lux which was the aim. Besides, during lunch break all the lighting system is shut down for one hour. If some employees want to continue to work during lunch time, then they have to dim their personal lamps.

- In air conditioning system, exhausted warm air heats up incoming fresh air via serpentine and stainless spiral tube halves during its exit in winter. In summer, exhausted cold air cools the incoming warm air a little during its exit. By this way high efficiency rates in air conditioning system are achieved both in summer and winter times. Besides, there are four pipes that go through FCUs and provide both cooling and heating. There are also carbon monoxide and nitrogen sensors in

parking area. Since the capacity of the park is almost 150 cars, it is important to control the amount of these gases.

- The most important innovation in the building is full automation of all electromechanical systems. There are more than 10,000 units connected to the automation system. The solution partner for the automation was *Siemens* and user panel of the system is in Turkish language. The panel is controlled by two people: Interviewee 11, technical manager of the building, and Interviewee 12, control technician. Even when they are not in the building, they are able to control the system twenty-four-seven via a mobile phone application. All sanitary installations, electromechanical systems, HVAC technology, firefighting, air quality control system, security equipment, internet server, sound systems within the building, entrance and exits of the building are controlled via this automation system. The main control room is on the basement floor under Interviewee 12's thumb. Besides, all information and measurements achieved from sub metering devices in all systems are archived in order to be compared when needed. Temperature, moisture, pressure and light intensities of all rooms, halls, corridors, toilets, kitchen, cafeteria, parking garage can be easily adjusted from the control room with one click. Breakdowns are determined immediately and then fixed. Conditions in critical places like engine room, garage and IT room are always followed. Software program of the automation system is periodically upgraded. Daily, weekly and monthly reports of consumption rates are prepared via measurements provided by the system. Each floor's, room's or system's consumption rates can be found in these reports. By making use of these reports, improvements in electromechanical systems are made regularly in order to achieve higher efficiency rates.

4.5.5. Barriers

The project team did not hear about LEED before the project began. They were unfamiliar with its standards hence they needed to be informed about the process at the very beginning. They made an effort in order to master the subject and improved themselves in knowing LEED principles.

The only difficulty that the team encountered during the project was consumables without LEED certification. For example, the project team procured hand soaps in compliance with European standards however soaps did not have any LEED certification hence such products were not acceptable according to LEED rating system. The team had difficulties in procuring especially cleaning materials.

4.5.6. Enablers

Since the company installed electromechanical systems of the latest technology and invested heavily in the headquarters building after purchasing it in the form of core and shell, there was almost no need for additional investments in order to achieve LEED certificate and this accelerated the project process.

The company shoulders its environmental responsibility strongly. As an example, they insisted on purchasing environmental friendly consumables even though LEED did not accept some of them as green materials.

Since the company is an engineering design company, both its project team and the employees in the building got used to new implementations easily and understood LEED principles and standards. This provided a quick adaptation to implementations in the building.

4.5.7. Benefits at Project Level

Fifteen percent drop in light intensity that cannot be realized by human eye directly affected electricity bills. As a total, there is 27% saving in gas consumption, 20% in electricity and 31% in water use after energy efficient tools implemented in Building E. These percentages were achieved by comparing consumption rates that were measured before energy efficient tools were implemented with values that were recorded after certification process was completed. The savings in energy can be seen as a certain success of the full automation system within the building.

4.5.8. Benefits at Organization Level

According to Interviewee 11, the most important benefit was that an environmental awareness was created among employees. Besides, information of reduction in carbon emission and savings in consumption rates is regularly shared on the company's web site.

Although image of a company is not a quantifiable measure, the company executives think that having a green headquarters building is a correct strategy for a firm making business in energy sector in accordance with image of the company. In Second International Summit of Green Buildings in Istanbul the company was awarded due to its project of headquarters building in Ankara.

4.5.9. Lessons Learned

Greening an existing building that was constructed with qualified materials and equipped with efficient mechanical, electrical systems causes almost no extra expenses. Then it is very easy to certify the building under LEED since standards are already achieved.

Interviewee 11 says: "*Turkey is poor of energy resources. A large amount of needed energy is imported from abroad. The less energy is consumed the less our country is dependent on external sources*."

As a last word, facility management sector in Turkey is not developed very well although it is crucial for achieving high efficiency in structures. Especially, old buildings are equipped with inefficient mechanical systems and have poor heat isolation. Structural characteristics and operating activities of public buildings are extensively problematic. The government must take action quickly and start converting its buildings to efficient ones or even to green ones. No doubt, this would provide achieving great economic benefit for Turkey.

4.6. Case 6

4.6.1. General Information

Owner of Building F is a global firm making business in food sector with an endorsement value of 11.6 billion TL in 2011. The company has 46 factories in Turkey and nine factories abroad. There are 30,000 employees working within the structure of the firm. It is stated in the mission of the company that they respect the environment and continue performing their social responsibility tasks.

One of the company's campuses is located on Anatolian side of Istanbul. There are four buildings in the campus and 1,000 employees working there. Company executives once decided to make the office buildings as a whole green campus by converting four structures to green buildings. However, the consultancy team did not find it feasible. According to them, converting the buildings one by one was a more affordable action hence executives decided first to convert the administration building which was constructed in 1993 and reinforced against seismic forces in 2001. There are 400 employees working in that building. The project team started to work in order to get LEED certificate for the administration building in the beginning of 2011 and after a relatively long time, in January 2013, the building was certified under LEED for Existing Buildings Operations & Maintenance (version 2009) achieving 50 points and silver certificate. During project period, Consulting Firm I provided LEED consultancy services.

4.6.2. Drivers

The company performs green projects about energy efficiency and savings. On the one hand amount of waste material that come up during production stage in factories were reduced owing to an effective waste management within the company on the other hand the company uses packages that easily dissolve in the nature. The main aim was to reduce carbon emissions in order to provide environmental sustainability. The company also conducts a campaign cooperating with Ministry of National Education and public

universities. The campaign aims to inform primary school students about renewable energy resources and nature protection.

In factories of the company use of gases that are bad for ozone was minimized, burning systems are regularly maintained in order to improve efficiency and energy consumption generated from renewable resources is promoted. The most sizable investment about environmental sustainability was made in one of the milk plants. With an investment of 8 million TL it was provided that wastes of the plant are sorted and collected in a reactor. In the reactor anaerobic reactions take place so methane is produced with an average amount of 7,000 m^3 per day. This methane is burned in cogeneration unit and electricity is generated. The amount of energy generated in one year is equivalent to 3,580,000 m^3 natural gas. By this way 9.872 tons of carbon emission is prevented each year.

As it can be seen from the above examples, the company's mission and environmental responsibility duties do not remain unfulfilled. The firm plays an important role in Turkish public opinion and keeps performing its aforementioned social tasks. Hence converting its campus to a green one is a proper decision to the company's social and environmental responsibility policy. Apart from this, the administration building needed to be renovated since it was an old structure so renewal works had been scheduled before LEED certification process began. So it was an example of good timing that renovation works and LEED process were performed at the same time.

4.6.3. Resources

There is a strong department of environmental engineering within the company and LEED certification project was proposed by engineers from this department. The department is reporting to directorate of emergency management that attends to possible cases of environmental disasters, disposal of factory wastes etc. Project of greening the company's office facilities in Istanbul into green buildings was submitted to the top management and approval was received. Besides, the consultant firm was proposed by director of emergency management unit. In this way the project started. The team consisted

of Interviewee 13 who is manager of administrative affairs and facility manager, an environmental engineer, an outsourced mechanical team, an electrical engineer and an electrician. On the one hand they conducted meetings regularly that consultancy team also joined on the other they kept on performing their routine works.

About procurement of construction materials in green building projects Interviewee 13 says: *"We procured electronic products very easily. However there is great problem in supplying cleaning consumables that must be used in green buildings: There is no sufficient number of suppliers in the market. If we have chance, we could find some cleaning materials but they are in no way feasible because of their stiff prices. Market should be improved."*

Total budget of the renewal works performed in order to get LEED certification in Building F was about 200,000 TL. Toilet improvements that would be performed independently of LEED process took only a small percentage in project budget whereas lion's share belonged to improvements in ventilating installations. Their cost was about 80,000 TL and a large amount of labor force was needed. Besides, more than 500 mechanic ballasts were replaced with electronic ones in the building. These work items were the main cost factors of the project.

4.6.4. Tools

Table 4.18. LEED scorecard summary of Building F.

LEED-EB 2009 Credits for Building F		
Categories	**Possible Points**	**Points Won**
Sustainable Sites	26	16
Water Efficiency	10	7
Energy and Atmosphere	35	15
Materials and Resources	14	4
Indoor Environmental Quality	15	1
Innovation in Operations	6	4
Regional Priority Credits	4	3
Total	**110**	**50**

- Aerators were implemented in all taps of the building. All reservoirs were replaced with ones with capacity of 3 or 6 liters. Measuring devices were placed in sanitary installations in order to follow amount of water used in the building. Besides, water uses of car wash garage and landscape irrigation are being followed separately. Two gardeners record these amounts and one supervisor establishes tables of consumption and follows the records.

- In exterior lighting, 30 fixtures were replaced with efficient ones. The old ones were positioned facing upwards and brightening the sky. The new are positioned facing downwards so they work more efficiently. All mechanic ballasts in lighting fixtures were replaced with electronic ones. Electronic ballasts provide more efficient electricity consumption and a longer economic life for lamps when compared with mechanic ones since they adjust operating frequency and limit the amount of current in lightening fixtures. Besides, all fluorescent lamps were adjusted according to T5 standards and mercury in lamps was reduced.

- It is a prerequisite for LEED certification to provide fresh air entering the building. For this reason, more than 1,000 measuring devices were placed at ventilating openings in all rooms. By this way, the amount of fresh air supplied in each room is recorded. The project team showed LEED officials in the USA that the building fulfilled the prerequisite of sufficient ventilation by sending results of the measurements, building plans and a legend. All gases used in air conditioning system were replaced with ozone friendly gases.

- There are measuring devices in all sanitary, ventilating, electrical and natural gas installations in order to follow consumptions.

- Since back side of the campus faces forestland, disinfection in the buildings is important. The project team implemented environmental friendly methods so biodiversity was not harmed. All used insecticides had material safety data sheets. Such different control methods did not bring any extra cost.

- During LEED process, number of transportation services was increased and their size was also enlarged. Furthermore, different routes were added to existing routes so number of employees who take these services increased from about 650 to 850. Almost each employee except for directors and managers are transported via shuttle vehicles. With this practice, it was aimed to reduce carbon emissions.

- Electricity is provided from a private company generating power from renewable resources like wind or geothermal energy. The company has *certificate of free consumer* and owing to this the company is able to buy electricity from private power suppliers. This certificate can be owned by firms that pay more than 3,000 TL for electric bill and it provides also that companies reach cheaper energy. Apart from this, electronic products with Energy Star logo were chosen in the building so that electronic devices consume less energy.

- Electronic wastes of the campus are collected by a firm that prepares reports at the end of each year indicating how many tons of waste were recycled during the year. Besides, classified wastes like plastic, glass and metal are given to the municipality. The company does not make money from these recycling works yet. They support such services for environmental sustainability at the moment. Last but not least, organic wastes coming from the cafeteria and garden are collected in a composting machine so a small amount of organic fertilizer is produced. This compost is used in garden of the building.

- It was determined that each month 60,000 plastic cups are used in water dispensers in the office. Since it is a large amount of consumption, the project team decided to use cups made of recycled paper. All papers being used in the building have FSC license. Lastly, during conversion works, paints and adhesives with low VOC content were purchased and used.

4.6.5. Barriers

During renewal works, there was some impracticability arising from that the office building was an old structure. Since design of the building was inadequate and ventilating system was out of date, lack of daylight and fresh air were the main challenges that the team encountered during project period although there was no constraint in the project budget. The campus is located in a district of Istanbul where dense housing exists. Even distance between the office building and its neighbors is just 1.5-2 m in some places. Such close positioning of buildings in neighborhood causes that the office building cannot receive daylight properly. In addition to these, the campus is located in a protected area which means that no renovation or construction works can be performed on the roof or façade of the building. This prohibition is imposed by law.

The project team had difficulty in finding furniture suppliers that sell products in compliance with LEED standards. Interviewee 13 says that it is very hard to find wooden products made of recycled materials or that contain no chemical compounds in Turkey. Although there is small number of such suppliers, they are unable to provide economic products. Cleaning consumables in compliance with LEED standards were also not found during project process.

The project team wanted to build a rainwater store reservoir and a system that would pump collected water to reservoirs. However, sanitary system in the building had to be rebuilt in order to provide rainwater to be used in reservoirs. Because such a system would cost about 400,000 TL, it was abandoned to implement such a system. Interviewee 13 explained the situation: "*To pump rainwater to reservoirs in existing buildings is a difficult job. The whole sanitary system should be reinstalled again*."

Since this would be a green building certified under LEED, it was forbidden to smoke both inside the building and within a distance of 7-8 meters from the office. Nevertheless, some employees felt uncomfortable because of this prohibition. Some of them thought that it was unfair that smoking was forbidden in only one of four buildings in the campus so they wanted to defy the ban.

4.6.6. Enablers

During the whole project, Consulting Firm I helped the project team reach their goals in greening process. Interviewee 13 says: "*Our consultant team had very good relations with LEED organization in America. Their accumulation of knowledge was wide and it was seen that they enormously invested in their LEED consultancy services. Due to these properties, the consultancy team helped us through a tiring period*."

Top management of the company supported the project from the beginning both financially and morally so the team was motivated to complete their job. For instance, there was a well-known garden in the middle of the campus however, according to LEED principles it was an unwelcome property that the garden was covered with grass since it is a plant that needs much of water. Top management of the company did not object the decision that the garden would be removed and other herbs would be planted instead of grasses in order to meet LEED requirements.

4.6.7. Benefits at Project Level

It is estimated that there is 40% saving in water use and 10% in energy consumption after LEED certification of the building. However, more accurate results can be seen after some months or at least one year later since the building was certified under LEED just some months ago.

According to Interviewee 13, it is hard to measure success in imponderable concepts such as recognition, image and comfort. He thinks that employee satisfaction increased after greening the office building and says: "*Each effort invested in green building implementations enhances employee satisfaction*."

There is an awarding system for innovation projects within the company which has been continued for years. Each year some projects are awarded which were carried out by employees of the company in the recent year. Interviewee 13 believes that his project team will win this award this year and he will be proud of that.

4.6.8. Benefits at Organization Level

The project team intends to green other three buildings and have a green campus at the end of the project period. Thereafter, it would be scheduled that other campuses of the company would be greened. The conversion of Building F showed the company executives that it was possible to have a building certified under LEED. They believe that return of the investments would be large and the green building would contribute an important share in the company's yearly returns. They think one of the remaining buildings would receive another silver certificate of LEED and two of them would only be certified under LEED since other buildings would have certain disadvantages in a greening project.

Interviewee 13 explains his pleasure of completing a green building project with his own words: "*We are proud of the project, certified under LEED. It was an important and prestigious project. Recognition of LEED and awareness of green building concept in community increases progressively. We are pleased that our project is mentioned in places where issues about sustainability and environmental responsibility are of the topic*."

4.6.9. Lessons Learned

Firms must pay attention to prerequisites of LEED before they start a certification process. They had better fulfill the prerequisites first and then apply for a certification under LEED since companies may have difficulties in proceeding to next steps. Interviewee 13 underlines the importance of LEED prerequisites.

Characteristic properties of buildings that become candidate in green buildings are of capital importance since these properties may accelerate the certification process but they may also complicate the situation and prolong the project period.

4.7. Summary of the Case Studies

Findings from the six case studies are summarized in Table 4.19.

Table 4.19. Summary table of case studies.

	General Information	Drivers	Resources	Implementations	Barriers	Enablers	Project Outcomes	Project Benefits	Lessons Learned
Building A	• Owner is a private company founded in 1961 and is a member of TCA. • The building serves as headquarters of the company, located in Istanbul, was built in 1987, renovated in 2008 and about 300 employees work there. • It is certified under LEED-EB and silver certificate is achieved in August 2011.	• The company published the Sustainable Life Report in 2006 and undertakes corporate social responsibility projects about saving of water and energy. They are a member of CEDBIK.	• Real estate development team was in charge of the project. • Consulting Firm I was chosen as LEED consultant. • Completing the certification process took 10 months. • Because of the last renovation, there was no need to spend much money in the project.	• Terrace roof and the ground around the building are covered with light colored materials. • Old water armatures are replaced with efficient ones. • Local and adaptive plants exist in the garden. • Seventy percent of employees take service shuttles. • LED lamps are installed. • Mechanical ventilation is provided.	• LEED approved cleaning consumables cannot be supplied and a cleaning company that services according to green building standards does not exist in Istanbul.	• The project team worked with environmental responsibility and was continuously supported by the senior management of the company. • Employees took kindly to improvements in the building.	• 12.310 kg of paper; 20 kg of plastic; 150 kg of metal; 1350 kg of debris; 105 kg of glass and 20 kg of batteries were delivered to the municipality in order to be recycled. • There is 11% saving of water, 24.9% of gas and 5.7% of electricity. • Thermal comfort reached 63% and internal air quality reached 76%.	• The first building in Turkey certified under LEED-EB. • Brand value of the firm increased.	• It is possible to complete the green retrofit project with a small budget if efficient adjustments are made in building management method. • Instead of LEED, a Turkish green building assessment system is required.
Building B	• It is a six storey building owned by a couple and built in the late 1880's. • The building serves as a hotel in Istanbul and is the first heritage building certified under LEED. • It was certified under LEED-NC in June 2011 and silver certificate is achieved.	• Life cycle analysis showed that the return of an investment in a green renovation project would be large. • Architect of the project mastered herself in ecologic structures hence she tried to convince the owners to renovate the building according to LEED standards.	• All construction works took nine months. • Consulting Firm I was LEED consultant of the project. •Construction materials were supplied from local firms. • The additional cost of LEED certification process was 5% of the total project budget.	• External walls are coated with self-cleaning paint. • Adhesives with low VOC content were chosen. • Green roof was used. • Internal air quality monitors were installed in the rooms. • All electrical household appliances were chosen from class A in energy efficiency.	• Since the building is a historic structure, there were some LEED points that the project team could not attend.	•Structural performance of the old building was satisfying hence there was no need for reinforcement works. • The subcontractor of the project was a skilled firm. • Owing to smart procurement planning, there was no problem in supplying the products.	• There is 25% saving in energy consumption and 28% in water use.	• The owners expect large amounts of earnings in the long run.	• Procurement planning is a crucial stage of the project. • A Turkish environmental performance assessment system is required in order to remove inconsistencies of LEED that occur when compared with Turkish standards.

Table 4.19. Summary table of case studies (continued).

	General Information	Drivers	Resources	Implementations	Barriers	Enablers	Project Outcomes	Project Benefits	Lessons Learned
Building C	• It is a dormitory of a public university located in Istanbul. • The building is a five storey historical monument built in 1871. • It was certified under LEED-NC in October 2012 with a gold certificate.	• It is set forth in the university's strategic plan so that every new building that will be built in the future should be green and a candidate for LEED certification. • It is stated in the university's vision that becoming green and sustainable is aimed.	• It took one year to complete all construction works. • Consulting Firm I was LEED consultant of the project. •Construction materials were mainly supplied from local firms. • The main cost of the project belonged to new mechanical installations.	• Bicycle parks were built. • Solar hot water system panels were placed. • In heating and lighting systems user controlled switches were implemented. • Grey water recycling system was set up. • Faucets with low flow rates are chosen. Urinals and reservoirs with low capacities were preferred.	• It was not indicated in the specifications that the building had to be renovated according to LEED requirements hence subcontractors were later ordered to work according to LEED standards of that they were unaware. • Budgetary constraints were put several times by the university.	• Project team members devoted themselves completely to greening of Building C and improved themselves in LEED knowledge. • The coordinator held a mediatory position between all the parties. • Consulting Firm II's team performed great amount of documentation work.	• There is 26% saving in energy and 43% in water use. • Students' satisfaction and comfort were increased.	• Project team gained experience in performing possible green building projects in the future.	• It was a major mistake of the university administration that it was not indicated in the project specification that the renovation would be carried out according to LEED standards. • The first project budget was not sufficient for such a green building conversion project.
Building D	• Owner is a private research company founded in 1998. • It is a main office building built in 1991 in Istanbul and there are 45 employees working there. • The building was certified under LEED-NC in March 2012 and achieved a gold certificate.	• The company has a strict environmental responsibility policy.	• Well-known supplier brands were chosen as solution partners • Architect of the project was in charge of design, construction, supply and management of the process. • Consulting Firm III was LEED consultant of the project.	• Acclimatization was provided with air conditioners. • Sensor faucets with low flow rates and waterless urinals and reservoirs with small capacities were chosen. • In landscaping local plants were chosen. • Ninety percent of life spaces receive daylight with an intensity of minimum 250 Lux. • Glasses with high insulation rate were used.	• It was very hard to get material content reports from suppliers or subcontractors. • The subcontractor responsible for technical infrastructure works could not provide full automation in • It was a time loss converting measurements to American units and translating all the documents.	• Consulting Firm III led the project team both in finding proper suppliers and in documentation process. • Technical problems were solved via solution partners.	• Fresh air is supplied 30% more than what is stated in ASHRAE standards. • There is 23% saving in energy consumption and 40% in water use.	• LEED certification brought prestige to the firm. • The company was awarded by CEDBIK.	• Full automation of ventilating, heating and electronic systems could not be provided because of inappropriate subcontractor choice.

Table 4.19. Summary table of case studies (continued).

	General Information	Drivers	Resources	Implementations	Barriers	Enablers	Project Outcomes	Project Benefits	Lessons Learned
Building E	• Owner is a contractor company founded in 1959. • The building is the headquarters of the company in Ankara and has a total of 20.000 m^2 construction area. There are 380 employees working there. • It was certified under LEED-EB in November 2012 with a gold certificate.	• The company is doing business in energy sector hence they think that a green office building is a must for them because of their environmental responsibility.	• Fifteen thousand dollars were spent during certification process. • The project team consisted of experts from many different fields. • Consulting Firm IV was LEED consultant of the project.	• City water is first treated in a treatment system before it is consumed. • A preventing maintenance plan for systems was formed. • Filter layers preventing ultraviolet lights were placed in the glasses. • Intensity of the whole lighting system was reduced. • Full automation of all electromechanical systems was provided.	• LEED approved products, especially cleaning consumables, were hard to supply.	• Employee culture provided a quick adaptation to greening. • Since the company installed electromechanical systems of the latest technology and invested heavily in the headquarters building before, there was almost no need for additional investments in order to achieve LEED certificate.	• There is 27% saving in gas consumption, 20% in electricity and 31% in water use.	•Environmental awareness was created among the company's employees.	• Greening an existing building that was constructed with qualified materials and equipped with efficient systems brings almost no extra cost.
Building F	• The building is an office building of the owner company making business in food sector. There are 400 employees working there. • It was constructed in 1993 and reinforced against seismic forces in 2001. • The office building was certified under LEED-EB in January 2013 with silver certificate.	• The company has a strong environmental responsibility policy and performs green projects about energy efficiency and savings in Turkey. In its factories, it is also aimed to reduce carbon emissions.	• Consulting Firm I was chosen as LEED consultant. • Total budget of the renewal works performed in order to get LEED certification was about 200.000 TL. • The company's department of environmental engineering was very helpful to the project team.	• Aerators were used in all taps. • In exterior lighting, fixtures were replaced with efficient ones. • Sub metering devices were set up in all installations. • Number of transportation services was increased. • Electricity is provided from a private company generating power from renewable resources.	• There was impracticability arising from that the office building was an old structure. • It is hard to find wooden products made of recycled materials or that contain no chemical compounds in Turkey. Cleaning consumables in compliance with LEED standards were also not found during project process.	• Consulting Firm I helped the project team reach their goals. • Top management of the company supported the project from the beginning both financially and morally.	• There is 40% saving in water use and 10% in energy consumption. • Employee satisfaction was increased.	• Completing the greening process successfully brought prestige. • The company decided to continue greening their structures.	• Firms must pay attention to prerequisites of LEED before they start a certification process. • Characteristic properties of buildings are of capital importance for LEED certification.

5. DISCUSSION

Based on the information gathered from the case studies and critical review of the literature, research findings are discussed in accordance with the nine components of the framework adopted for the research. Commonalities and differences in six green retrofit projects in Turkey are identified and components of the greening process are examined in detail. Conclusions drawn upon the findings and discussions along with the recommendations are provided in the next chapter.

5.1. General Profile of Green Retrofit and Renovation Projects

There are ten green retrofit or renovation projects certified under LEED in Turkey (USGBC, 2013). Four of them are certified under LEED for Existing Buildings of Version 2009 and the remaining six were certified under LEED for New Construction and Major Renovations of Version 2009. Five of them have gold, four have silver and one of them has platinum certificate. Among green retrofit and renovation projects, the first LEED certification in Turkey was awarded in 2011 and new applications for the certification exist.

When the six projects investigated in this thesis and other remaining four green retrofit projects are considered together, it is seen that there is only one public building which was renovated and then certified under LEED. All other nine green retrofit projects were performed by private companies in Turkey. Like in many other fields, private sector in Turkey led the field of green building implementations. It is not a coincidence that these ten projects are located in Istanbul, Ankara, Izmir and Kocaeli that are the most industrialized and developed cities of Turkey where private companies are densely gathered.

Buildings investigated in this thesis are generally older than twenty years old. Before they were certified, the buildings were underperforming in terms of efficiency and comfort so their owners were willing to green retrofitting once they were aware of LEED.

There are two heritage buildings that were built before 20th century, renovated and then certified under LEED. Green renovation is a chance to enrich them and extend their lives.

5.2. Drivers

When five private companies and a university investigated in this thesis are considered, it is seen that all six have a common organizational strategy or approach that they have *strong environmental responsibility policies.* For example, the owner company of Building A has prepared a sustainable life report in 2006 which was a first step to foster sustainability in the Turkish construction sector. The company also conducts social responsibility projects about energy and water savings. The university where Building C is located has stated in its vision that greening its campuses and improving sustainability are the main tenets. It is also mentioned in the university's strategic plan that application for LEED certification for each new building is a must. Moreover, the university aims to reach a net zero carbon footprint in all campuses. Each employee working in Building D plants a tree every year. They have a memorial area in Istanbul that they forested. Executives of the contractor of Building E believe that having a headquarters building that does not harm the nature and pollutes less is a must for them since they are a company in energy sector. Owner company of Building F carries out social responsibility campaigns of energy efficiency. In its factories an effective waste management is followed and packages are used that easily dissolve in the nature. The main aim of the company is to reduce its carbon emissions. Since these organizations aim to improve environmental awareness in Turkey, they all leant towards green building concept.

When Buildings A, E, D and F are considered, one of the main reasons why company executives decided to green their office buildings is to increase *employee satisfaction.* It can be said that private companies aim to increase employee productivity by improving internal air quality in the offices. Although literature review presented different business, social or environmental reasons for green buildings such as market transformation and demand, environmental regulations, global competitiveness, creating sense of community, protecting natural resources or higher return of investment, none of the interviewees called any of these reasons. All project owners believe that greening their

structures is the right thing to do according to their environmental responsibility policy. Since LEED's popularity in Turkish society increases gradually, these certification projects are seen as examples of branding and public relations work. In the projects examined in this thesis, a detailed life cycle assessment or at least a cost benefit analysis was performed before starting. Life cycle studies presented large amount of savings in the long run whereas clients in Turkey generally look for investments with shorter payback periods. In these studies, owners saw estimated reductions in energy consumption and water use and also savings in operational costs. It was another reason how owners are convinced to implement green retrofit projects.

5.3. Resources

Human resources are crucial in LEED certified building projects since there are not many professionals and experts in Turkey who have comprehensive knowledge of LEED criteria. It is important to have professionals in the project team from different disciplines because LEED criteria include different requirements from many fields. Owner company of Building A had its real estate development team cooperating with other teams of the firm. The project team working for Building C consisted of architects, mechanical engineers and civil engineers. Contractor of Building E teamed engineers, technicians and professionals from corporate communications and quality assurance. In the project team of Building F, a mechanical team, an electrician, an electrical engineer and an environmental engineer with the green retrofit project were charged. In the projects of Building B and D, architects were the project leaders. Besides, four different firms served as LEED consultants in the six projects. Since green building concept is new in Turkey, all organizations needed consultancy service during their retrofit and renovation projects in order to get LEED certification. These projects gave the opportunity to client organizations, professionals, contractors and subcontractors of improving themselves in green building and LEED concepts.

Since Building A went through a major retrofit before LEED certification process, there was no ***extra cost*** for the certification process. The project team of Building B calculated extra cost of greening the structure and it was found that extra cost was 5% of

the total project cost. The main expenses of green retrofit project of Building C were mechanical installations and precautions taken in the site not to pollute the environment. Their cost was more than 40% of the project cost. In green building project of Building D, the only extra cost was because of waterless urinals. Otherwise, the major cost of the project belonged to LEED consultant firm. $ 15,000 was spent during certification process of Building E whereas 200,000 TL was the total budget of the renewal works performed in Building F. The interviewees agree that green retrofit or renovation project is not an expensive issue even that it is a suitable opportunity for clients.

Time is another important resource as much as money. Renewal works of the aforementioned projects took at least five and at most twelve months. However, application for LEED certification does not finish when construction works are completed. Companies must take into account the documentation process which may take longer if sufficient attention is not paid.

LEED criteria require to provide construction materials from *local suppliers* and to use LEED approved or environmental friendly products if possible. When looked at the six projects investigated in the case studies chapter, it is seen that paints and adhesives with low VOC content, wooden materials with FSC license and highly insulated glasses were generally chosen as frequently used construction materials. Although project teams intended to work with local suppliers, sometimes global companies were chosen because of innovative solutions they offer so it is not a coincidence that some solution partners of the projects are the same global companies. Local suppliers usually fail in providing content reports of their products. According to the interviewees, Turkish suppliers have lots to do catch up with other global firms. Nonetheless, there is not any major problem in supplying green building materials required by LEED in Turkish construction sector. Moreover, majority of green construction materials can be found in the market.

5.4. Green Implementations

Considering six different green renovation and retrofit projects, there are some common practices that were implemented in these projects in order to get more LEED

points and to green the buildings. Most common practices, except for LEED prerequisites, are listed below:

- Old water armatures are replaced with efficient ones and sometimes aerators are used in faucets in order to limit the amount of water flowing.

- Low capacity reservoirs are chosen in toilets.

- In order to reduce amount of water needed for irrigation, local and adaptive plants are preferred in gardens.

- LED lamps are chosen if existing lighting fixtures are old and work inefficiently.

- Old exterior lighting fixtures are replaced with new ones facing downwards instead of brightening the sky.

- In interior design, lamps enabling dim control and lighting fixtures with user controlled switches are chosen in order to prevent wastage of electricity.

- Carbon dioxide detectors are placed in critical places such as car parks.

- Adhesives and paints with low VOC content are chosen in order to protect human health.

- When design of the buildings is convenient, it is considered by the project teams to provide that all users receive daylight directly and they have a sufficient amount of light intensity in order to increase employee or tenant comfort.

- Project owners intend to provide construction materials and products from local suppliers since it is quicker and cheaper than providing from foreigners.

- If the green building is a main office of a company then shuttle vehicles are put into service in order to transport workers and to reduce carbon emissions arising from private cars.

- If basement floor of the green building is convenient then this floor is used as parking area in order to prevent heat island effect.

- Glasses with high heat insulation are chosen in windows if they are to be changed during renovation.

- Electronic devices and appliances in the buildings are chosen from products with Energy Star logo or from class A in energy efficiency.

- Sub metering devices are placed in electrical and mechanical systems in order to record and control water and energy consumption rates.

- Preventing maintenance plan of electrical and mechanical systems installed in the buildings is prepared.

When common practices mentioned above are considered, it is seen that green retrofit or renovation projects certified under LEED have certain advantages arising from the buildings' characteristics that bring LEED points. When other green implementations are considered, it is the general intention of the project owners that they choose green building *investments with short payback periods.* Investments with longer payback periods or the ones requiring high amounts of investment are not preferred by the owners. The main aim is to get maximum of LEED points with a minimum amount of investment.

Among six investigated projects, there are some *unique or infrequent green implementations* that must be emphasized in order to present that they are applicable in Turkey and must be taken into consideration for the coming green retrofit projects. They are listed as indicated below:

- Green roof implementation is an appropriate measure in order to prevent heat island effect in crowded cities where buildings are densely located. It is also an effective measure for thermal insulation. Where green roofs cannot be implemented, white roofs can be chosen in order to reflect sunlight and to prevent undesired heating in this way.

- Internal air quality monitors placed in rooms are efficient practices in order to follow instantaneous air quality. They are especially important for office buildings where many people are found together in the day time.

- Reserving a parking area only for bicycles in a car park is an efficient measure to encourage bikers. If people are convinced to come to the job by bike then it is an opportunity for reducing carbon emissions originating from vehicles.

- Via a grey water recycling system, waste water from bath and washbasin is treated and reused in toilet reservoirs. It is an efficient way to save water in wet areas.

- Solar shading systems are required when one or more sides of a building receive the daylight directly during the day. The system help the building reject solar heat. Since air conditioning is sometimes an expensive way of keeping cool in summers, solar shading is an effective alternative.

- A small water treatment plant can be chosen to be implemented in green buildings in order to reduce amount of used cleaning materials. The city water can be first treated in the system and then delivered.

- Consuming clean energy is another important aspect. Supplying electricity from private companies that generate power from renewable resources is promoted in Turkey by giving opportunity to companies for choosing any supplier they want if they consume more than a specified amount of energy.

- Full automation of all electromechanical systems in Building E is a unique example of successful green building implementations in Turkey. Via this technology, each life space in the building is under control of the technical manager in terms of energy consumption, water use, thermal comfort and air quality.

5.5. Barriers

If building characteristics are not appropriate for a green retrofit project then the building becomes a barrier to certification process. For example, some buildings are *poorly designed* hence they may not receive daylight properly, have poor thermal insulation, may be equipped with inefficient electrical or mechanical systems etc. Such buildings have disadvantages in green retrofit or renovation projects since it is expensive to green them. Heritage buildings also have some disadvantages arising from prohibition of changing their appearance. Besides, it is another problem when old buildings do not have any sub metering devices in their installations since then it is impossible to compare new consumption rates with old ones.

There are several difficulties project teams encountered because of LEED's documentation system. Interviewees believe that understanding all LEED specifications and filling the documents in English *language* is an inconvenient way in itself since everyone does not have to speak English who are assigned in green building projects. Translation also takes time. It is also sometimes needed that documents must be sent to the USA and come back from there which is another time consuming period. When hundreds of documents are considered, it is seen that applying for a LEED certification is an operose process. The number of experts or professionals who mastered LEED, ASHRAE or any other American standards in Turkey is limited hence project teams simply have to get LEED *consultancy* service from third parties. It is nearly impossible for a project team to complete a certification process in Turkey without any support from LEED consultants.

Although there is a wide range of construction materials that can be used in green retrofit or renovation projects in Turkey, there are also some *unavailable materials* required by LEED. Green cleaning consumables are the most difficult ones to supply from

Turkish market, almost all project teams encountered difficulties in this issue. Some Turkish suppliers are incapable of providing their product's content report which is strongly required by LEED. Without such a report, it is impossible to understand if a product is made of environmental friendly or recycled materials. LEED approved materials are also hard to find in Turkey.

Lack of *building management* is another issue that the interviewees complained about. Before applying for a green building certification, companies must improve their building management techniques. Without an effective building management, it is meaningless to convert the building to a green one. However, with small adjustments in daily operations within a building, it is possible to save large amounts of water and energy.

5.6. Enablers

One of the most common practices that eased the greening process is *cost benefit analysis.* In all six projects energy efficient implementations were chosen according to the results of cost benefit analysis. Owners usually chose investments with shorter payback periods and stayed out of investments of which costs are more than their benefits. By this means, projects were completed with tight budgets.

Project teams are the most crucial party in green building projects. Their ***self-devotion*** is one of critical success factors in LEED certification process. Without their praiseworthy effort, green building certification projects cannot be accomplished since there are many critical issues in LEED of that the project team must take note such as translation, clear documentation, correspondence etc. In such a busy working environment, there are two important factors affecting performance of the project team. The first factor is the role of LEED *consultancy firms*. Consulting firms help the project teams prepare necessary documents, understand LEED principles, choose appropriate suppliers, reach experts etc. They play an important role both in construction and especially certification processes since project teams are not well-versed in LEED as much as consultancy teams. The second is the role of *top management*. When top management of the organization

supports the process from beginning to end and motivates the personnel then the project team works in a more independent, motivated and efficient way.

It is a great opportunity that the building has a satisfying *structural performance* if it would be renovated or retrofitted according to green building standards. It is an advantage in terms of cost of the project when structural retrofitting is not required for an old or historic building. If renewal works were performed on the building before applying for a green building certification, it is another advantage of the project which accelerates the process.

Another important enabler of the green building projects is the solution *partners* that help project teams procure green construction materials and products. Turkish and foreign suppliers have a wide range of products to be used in green building implementations of air conditioning, water armatures, windows, installation pipes, LED lamps, furniture, paints, adhesives etc. When needed, these companies also offer innovative solutions for their clients.

5.7. Benefits at Project Level

When six projects investigated in this thesis are considered, there are certain *savings in gas, electricity and water* after implementation of green building measures and certification under LEED. Savings in water range from 11% to 43%, in electricity from 5.7% to 20% and in gas from 24.9% to 27%. Reduction in general energy consumption rates deviates between 10% and 26%. These are proofs of reduction in operational and maintenance costs of green buildings.

Employee *satisfaction* in office buildings, student satisfaction in the dormitory and client satisfaction in the hotel building are increased after certification under LEED. These are determined via conducted surveys and comments from the building users. Thermal comfort of the users reaches until 63% and internal air quality satisfaction until 76%. Besides, more fresh air is supplied in the buildings reaching a rate of 30%. Unfortunately,

there is not any information about effects of improved environmental quality on productivity and enhancement of health.

Recyclable wastes taking their sources from the buildings are collected differently from other waste materials and transported to recycling plants in order to be reused. This leads to a *reduction in solid waste* amount. Although it is not measured, interviewees think that carbon emissions of their buildings are reduced after implementing green building measures.

5.8. Benefits at Organization Level

Benefits of the projects explained in this section are usually hard to measure. The only measurable benefit at organizational level determined in this study is the expectation of the interviewees that there will be a positive effect on expenditures of the buildings which will cause large amount of *earnings in the long run*.

Interviewees believe that their companies' corporate image was improved after getting a LEED certification. The certificate brought prestige to their corporations. Through completing successful green retrofit and renovation projects, organizations won ***national awards*** which caused that their recognition among the public was increased. All of the six projects were in line with the organizations' visions and missions based on their environmental responsibility policies. Environmental awareness among the end users was also increased.

5.9. Lessons Learned

According to the interviewees there are important aspects that must be taken into consideration when a green retrofit or renovation project is considered. For example, to green existing buildings is not expensive as much as people believe. Instead of investing large amounts of money and man hours, improving building management methods is a more efficient way in order to satisfy green building criteria.

Interviewees believe that a Turkish green building performance assessment system has become a necessity and it is more desirable than LEED or BREEAM. There are inconsistencies between Turkish standards and LEED criteria and there is also difficulty of translating all documents and specifications from English to Turkish and vice versa. Therefore a Turkish rating system is strongly recommended by the interviewees.

Since green building projects are different from conventional constructions works, choice of appropriate contractors and subcontractors is a crucial success factor. If a subcontractor is unaware of green building or sustainability concepts then it is very hard to expect a satisfactory performance level in a green retrofit project. Choice of suppliers is another important aspect since some recycled construction materials or environmental friendly products are hard to find in Turkey. A procurement planning or supply chain partnering must be created before starting the green retrofit project.

Firms must pay attention to LEED prerequisites because certification process does not start unless these criteria are met. Building characteristics play a key role in meeting these criteria hence project teams must first consider their building's existing properties and then determine a realistic target. Otherwise certification process may be prolonged and then fail in the coming stages.

6. CONCLUSION

6.1. Scope of the Thesis

It is aimed in this study to investigate greening projects of existing buildings certified under LEED in Turkey. Case study is chosen as the research methodology. Six completed projects are selected and analyzed as case studies. In order to analyze the greening process of these projects, a research framework is established. Based on this framework, a total of nine components of the greening process are investigated. Findings of the research are compared with the results reported in literature review.

6.2. Conclusions Based on Research Findings

Based on the case studies performed, it can be concluded that in Turkey private sector leads the field of green building. However, Turkish government should attempt to green its buildings first because the state has got a huge amount of existing building stock and many of them are old buildings performing very inefficiently. Therefore, each year large amounts of energy and water are wasted causing also higher operation and maintenance costs. The government should be a pioneer in performing green retrofit projects and also promote green buildings by offering low taxes and insurance costs.

Greening process is mainly owner or client driven in Turkey. There are different reasons why owners choose to practice green building implementations. Aiming at increasing employee productivity, increasing end user satisfaction, reducing operation and maintenance costs and improving corporate image are some of the main reasons why owners decide to start green retrofit or renovation projects in Turkey.

Turkish organizations that intend to perform a green building project and get a LEED certificate are somehow forced to cooperate with independent firms offering LEED consultancy services since the number of experts in Turkey are very limited who have comprehensive knowledge of LEED, ASHRAE or any other American standards.

Owners in Turkey choose green building investments with short payback periods. Some of the general green implementations in buildings are small but effective changes in water efficiency, use of environmental friendly construction materials and products, increasing indoor air quality by providing more fresh air, replacing old lightening fixtures with energy-efficient fixtures and reducing number of commuting road trips by offering alternative transportation modes. It is the general attitude of Turkish owners to get maximum of LEED points with a minimum amount of investment.

Lack of LEED approved products, lack of building management skills, poor performance characteristics and inappropriate orientation of old buildings are the major barriers to green retrofit projects in Turkey. Besides, there are difficulties arising from the fact that LEED is an American rating system. It has major differences from Turkish standards and also written in English language which makes the communications more difficult. As discussed in the previous sections, establishment of a national certification system that reflects the conditions of the Turkish construction industry will be a solution in the long run.

The most important greening enabler is effective teamwork. Each party such as the owner, contractor, architect, suppliers, LEED consultants and technical team has their own roles and responsibilities. As long as they act towards the same goals, the process is operated smoothly. Collaborative working among the participants of such projects and strong commitment to the process are crucial for success. Long term partnering and supply chain partnerships are effectively used mechanism globally. Wider utilization of these systems in green projects will help ensure the project success.

In all of the green retrofit and renovation projects investigated in this study, significant amounts of savings were achieved in water use, electricity and gas consumptions. Therefore, operation and maintenance costs of the buildings were decreased. Besides, employee satisfaction and tenant comfort in renewed life spaces were increased. Solid waste amount was also reduced. Besides, the projects have contributed to conservation of natural resources. Despite the difficulties experienced during the process, the benefits overweight the disadvantages. Besides, once a project team completes a green

project, lessons learned will guide them in future projects and not only the process will be smoother but also the benefits will be higher both at the project and organizational level.

All the projects were in line with the organizations' visions and missions based on their environmental responsibility policies. As the project executives have also agreed, getting involved in a green building project is a good opportunity for the organizations in order to polish their image. Completing green retrofit and renovation projects brings prestige to these organizations. Besides, environmental awareness among employees increases after getting certified under LEED. Therefore, firms operating in the constructions sector should be encouraged to build green.

6.3. Recommendations for Future Work

It is expected that this thesis would be helpful for the owners who intend to green their real estate properties, engineers and architects who will be in charge of green retrofit or renovation projects and also the tenants who want to live in green life spaces and be a guide for them. Academicians researching about green buildings in Turkey, especially about green retrofit and renovation projects, should definitely benefit from this research, since the greening process of a majority of the certified existing buildings are examined in this study for the first time.

In order to strengthen the findings of this thesis and to diversify the resources used in it, a quantitative research method can be applied as a future research. Questionnaires and case studies can be used in the same study. To conduct a questionnaire on participants from different sectors and disciplines would provide a wider range of source of information and present different views from people who did not get involved with the construction of a green building project.

In the future, a new study can be designed and performed with an increased number of case studies and interviewees. Such a study will be helpful to compare the findings and observe the similarities and differences between the conditions. Considering that a full-scale urban regeneration is on its way in Turkey, interesting findings may be obtained.

APPENDIX : AN EXAMPLE OF LEED SCORECARD

LEED for Existing Buildings: Operations & Maintenance (v2009)

GOLD, AWARDED NOV 2012

SUSTAINABLE SITES — AWARDED: 15 / 26

SSc1	LEED certified design and construction	0 / 4
SSc2	Building exterior and hardscape Mgmt plan	0 / 1
SSc3	Integrated pest Mgmt, erosion control, and landscape Mgmt plan	1 / 1
SSc4	Alternative commuting transportation	12 / 15
SSc5	Site development - protect or restore open habitat	1 / 1
SSc6	Stormwater quantity control	0 / 1
SSc7.1	Heat island effect - nonroof	1 / 1
SSc7.2	Heat island effect - roof	0 / 1
SSc8	Light pollution reduction	0 / 1

WATER EFFICIENCY — AWARDED: 9 / 14

WEc1	Water performance measurement	2 / 2
WEc2	Additional indoor plumbing fixture and fitting efficiency	4 / 5
WEc3	Water efficient landscaping	2 / 5
WEc4	Cooling tower water Mgmt	1 / 2

ENERGY & ATMOSPHERE — AWARDED: 23 / 35

EAc1	Optimize energy efficiency performance	13 / 18
EAc2.1	Existing building commissioning - investigation and analysis	2 / 2
EAc2.2	Existing building commissioning - implementation	2 / 2
EAc2.3	Existing building commissioning - ongoing commissioning	2 / 2
EAc3.1	Performance measurement - building automation system	0 / 1
EAc3.2	Performance measurement - system-level metering	2 / 2
EAc4	On-site and off-site renewable energy	0 / 6
EAc5	Enhanced refrigerant Mgmt	1 / 1
EAc6	Emissions reduction reporting	1 / 1

MATERIAL & RESOURCES — AWARDED: 7 / 10

MRc1	Sustainable purchasing - ongoing consumables	1 / 1
MRc2.1	Sustainable purchasing - electric-powered equipment	1 / 1
MRc2.2	Sustainable purchasing - furniture	0 / 1
MRc3	Sustainable purchasing - facility alterations and additions	0 / 1
MRc4	Sustainable purchasing - reduced mercury in lamps	1 / 1
MRc5	Sustainable purchasing - food	1 / 1
MRc6	Solid waste Mgmt - waste stream audit	1 / 1
MRc7	Solid waste Mgmt - ongoing consumables	1 / 1
MRc8	Solid waste Mgmt - durable goods	1 / 1

MATERIAL & RESOURCES — CONTINUED

MRc9	Solid waste Mgmt - facility alterations and additions	0 / 1

INDOOR ENVIRONMENTAL QUALITY — AWARDED: 9 / 15

EQc1.1	IAQ best Mgmt practices - IAQ Mgmt program	0 / 1
EQc1.2	IAQ best Mgmt practices - outdoor air delivery monitoring	0 / 1
EQc1.3	IAQ best Mgmt practices - increased ventilation	1 / 1
EQc1.4	IAQ best Mgmt practices - reduce particulates in air distribution	1 / 1
EQc1.5	IAQ best Mgmt practices - IAQ Mgmt for facility additions and alterations	1 / 1
EQc2.1	Occupant comfort - occupant survey	1 / 1
EQc2.2	Controllability of systems - lighting	1 / 1
EQc2.3	Occupant comfort - thermal comfort monitoring	0 / 1
EQc2.4	Daylight and views	1 / 1
EQc3.1	Green cleaning - high performance green cleaning program	1 / 1
EQc3.2	Green cleaning - custodial effectiveness assessment	1 / 1
EQc3.3	Green cleaning - purchase of sustainable cleaning products and materials	0 / 1
EQc3.4	Green cleaning - sustainable cleaning equipment	0 / 1
EQc3.5	Green cleaning - indoor chemical and pollutant source control	0 / 1
EQc3.6	Green cleaning - indoor integrated pest Mgmt	1 / 1

INNOVATION — AWARDED: 4 / 6

IOc1	Innovation in operations	3 / 4
IOc2	LEED Accredited Professional	1 / 1
IOc3	Documenting sustainable building cost impacts	0 / 1

REGIONAL PRIORITY — AWARDED: 4 / 4

EAc1	Optimize energy efficiency performance	0 / 1
EAc3.1	Performance measurement - building automation system	0 / 1
EAc3.2	Performance measurement - system-level metering	1 / 1
WEc1	Water performance measurement	1 / 1
WEc2	Additional indoor plumbing fixture and fitting efficiency	1 / 1
WEc3	Water efficient landscaping	1 / 1

TOTAL 71 / 110

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

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