Analysis of Project Costs for Green Buildings in the UAE – A Case Study

تحليل تكاليف مشاريع المباني الخضراء في دولة الإمارات العربية المتحدة - دراسة حالة

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Abstract

Green buildings, or as they are sometimes called, 'Sustainable Buildings,' or 'High Performing Buildings,' are buildings which aim to fulfill occupant or user' needs and still be efficient in using power, water and other resources. They also help to protect the well being and health of occupants and users, while reducing the waste, pollution, and environmental impact.

Governments are being challenged to reduce their carbon footprint in a stepped approach by a specified timeline. Information on global energy provided in a commissioned report by the International Energy Agency (IEA), revealed that existing buildings of all types, consume above 40% of all power consumption, globally, and at the same time, create more than a quarter of the total carbon emissions throughout the world (Howe 2010). The seriousness of these findings and others, have led some governments to take strong measures to reduce the energy and natural resource consumption of buildings, along with their environmental impacts. One of the ways they have attempted to do this has been by using more rigorous approaches in the development and adoption of 'green building' standards for their building projects.

However, one of the barriers hindering other governments adopting sustainable building codes and practices is the issue of 'cost.' The general perception of green buildings is that they cost considerably more to design and construct than conventional buildings (buildings that have not incorporated sustainable features throughout their design and construction). The important question, therefore, is, 'are these claims that green buildings cost more and require more initial investment, actually true?' And if so, by how much?

From the literature review, there was a general agreement that green buildings are more environmental friendly than the conventional ones. Green buildings also outperform conventional buildings on many aspects such as operational cost saving, indoor air quality, lower energy and water consumption and better productivity. However, there have been many studies into the concept of cost premium of green buildings. Some of these studies have supported the 'higher cost premium' viewpoint, while others have refuted it. This has lead to a great deal of confusion among developers, government bodies and other relevant parties investigating or involved in the implementation of green initiatives.

In order to support or reject any of these studies, there is a very real need to conduct a proper, controlled study approach to determine the true additional cost green buildings will incur over and above conventional ones, if any. For this study the cost premium of green buildings in the UAE will be examined and analyzed in comparison to conventional ones. Therefore two methods have been used:

Method 1: Cost Comparative Approach

Two recent green buildings will be compared with two similar conventional buildings in terms of construction cost per square meter at a shell and core level. The comparison will include: HVAC (but will exclude air conditioning as the green buildings are connected to a centralized district cooling plant), completion of associated public spaces, and above or underground parking spaces. This comparative study will exclude the design fee, land price and finishing items.

Method 2: Interviewing all key stakeholders of the Masdar Headquarters Building project as a case study to understand the different cost elements of green buildings and to identify the practices that have been adopted to ensure the cost effectiveness of green buildings.

The outcome of the first method, it was evident that green buildings were not necessarily more expensive than conventional ones at the core and shell level. Any cost premium therefore could be attributed to other factors such as the meeting of client requirements on the finishing level, or the technology, which was installed and used, regardless of whether the building was green or conventional.

From the analysis of the feedback from interviewee, it was clear that sustainable buildings don’t necessarily require any additional investment compared to conventional ones If they done properly, as the cost driver is related primarily to the client’s specifications and the subsequent design, rather than sustainable elements. What was evident that a green building project team needs to work in an integrated way, particularly during the design stage, to control the overall project cost.

ملخص

المباني الخضراء أو كما تسمى أحيانا "المباني المستدامة" أو "المباني عالية الأداء" هي المباني التي تحقق احتياجات المستخدمين وفق كفاءة أفضل في استخدام الطاقة والمياه والموارد الأخرى مع الحد من التلوث البيئي.

تفيد المعلومات عن منظمة الطاقة العالمية في أن أكثر من 40٪ من استهلاك الطاقة العالمية ناتجة من المباني بكافة أنواعها وفي الوقت نفسه تنتج هذه المباني أكثر من ربع إجمالي انبعاثات الكربون في جميع أنحاء العالم (هاو 2010). أن خطورة هذه النتائج وغيرها أدت ببعض الحكومات على اتخاذ تدابير قوية للحد من استهلاك الطاقة والموارد الطبيعية للمشاريع باستخدام نهج أكثر صرامة في مجال تطوير المباني واعتماد معايير "المباني الخضراء" لكافة المشاريع.

بالرغم من هذه النتائج لا تزال كثير من الحكومات تواجه الكثير من التحديات في تطبيق هذه المعايير بسبب "التكلفة" حيث إن هناك تصور عام في أن المباني الخضراء تكلف أكثر بكثير من المباني التقليدية. السؤال المهم هو هل هذه الادعادات صحيحة؟ وإن كان الأمر كذلك، كم تبلغ هذه التكلفة؟

من خلال استعراض الدراسات السابقة، يوجد هناك اتفاق عام في أن المباني الخضراء أكثر استدامة من تلك التقليدية. كما يوجد اتفاق علي أن المباني الخضراء أفضل من المباني التقليدية في العديد من الجوانب: مثلا في توفير التكاليف التشغيلية، و في جودة الهواء الداخلي، و في استهلاك الطاقة والمياه. مع هذا توجد هناك العديد من الاختلافات في موضوع تكلفة المباني الخضراء، حيث أفادت بعض هذه الدراسات في أن المباني الخضراء تكلف أكثر من المباني التقليدية، في حين نفى البعض الآخر ذلك. هذا الاختلاف في النتائج أدى الى خلق قدر كبير من الارتباك بين المطورين والهيئات الحكومية والأطراف الأخرى ذات الصلة في تنفيذ المبادرات الخضراء.

من أجل دعم أو رفض أي من هذه الدراسات كانت هناك حاجة حقيقية لإجراء دراسة عملية لتحديد التكاليف الإضافية للمباني الخضراء إن وجدت. لذلك في هذه الدراسة سوف يتم فحص تكلفة المباني الخضراء في دولة الإمارات العربية المتحدة وتحليلها بالمقارنة مع تلك التقليدية وذلك باستخدام طريقتين:

طريقة 1: مقارنة التكلفة للمتر المربع

سيتم مقارنة اثنين من المباني الخضراء مع اثنين من المباني التقليدية المماثلة من حيث تكلفة البناء للمتر المربع بدون أعمال التشطيبات. كما سيم استبعاد رسوم التصميم وأسعار الأراضي من هذه المقارنة.

طريقة 2: مقابلة جميع العاملين الرئيسيين في مشروع مبنى مقر مصدر كدراسة حالة لفهم عناصر التكلفة المختلفة في المبنى و للتعرف على الممارسات التي تم اعتمادها لضمان تكلفة أقل للمشروع.

تشير نتائج الأسلوب الأول في أن المباني الخضراء ليست بالضرورة أكثر تكلفة من تلك التقليدية و أن التكاليف الأضافية يمكن أن تعزى إلى متطلبات المالكين على مستوى التشطيبات أو التكنولوجيا بغض النظر عما إذا كان المبنى مستدام أو تقليديي.

من تحليل ردود فعل العاملين الرئيسيين في مشروع مبنى مقر مصدر يمكن استنتاج أن المباني المستدامة لا تتطلب بالضرورة أي استثمارات إضافية مقارنة مع تلك التقليدية إذا تمت بشكل صحيح ولا سيما خلال مرحلة التصميم.

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Acronyms

AHU	Air Handling Unit
ASHRAE	American Society of Heating, Refrigerating, and Air Conditioning Engineers
ASTM	American Society for Testing and Materials
BEPAC	Building Environmental Performance Assessment Criteria – Canada
BRE	Building Research Establishment
BREEAM	The British Research Establishment Environmental Assessment Method
CEMP	Construction Environmental Management Plan
DAT	Decision Audit Trail
DOT	Department of Transport – Abu Dhabi
FCU	Fan Coil Unit
GRC	Glass Fibre Reinforced (cement)
GSA	US General Services Administration
HK-BEAM	Hong Kong Building Environmental Assessment Method
IEA	The International Energy Agency
IRR	Internal Rate of Returns
OPL	One Planet Living principle
LEED.	Leadership in Energy and Environmental Design
LEED AP	Accredited Professionals
MMC	Modern Methods of Construction
NPV	Net Present Value
PBRS	Pearl Building Rating System
PCC	Per Capita Consumption
PQP	Pearls Qualified Professional
PVRS	Pearl Villa Rating System
STMP	Abu Dhabi Surface Transport Master Plan
TSE	Treated Sewage Effluent
UPC	Abu Dhabi Urban Planning Council American
USGBC	United States Green Building Council
VOC	Volatile Organic Compound

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1- Introduction

Buildings can be viewed as living creatures, where they consume water, energy and other resources, and produce waste and pollutants as a result. They can also have a negative impact on, not only their surrounding environment, but also on the people who occupy or use them.

However, buildings can be designed, built and operated to do the opposite of this, or at least, to consume less resources and produce less waste. These buildings have come to be known as, 'Green,' 'Sustainable,' or 'High Performance' Buildings. Resource conservation and waste reduction are not their only aims, but equally important are the health and well being of the building users and occupants, along with its external environment.

International research studies have produced some alarming results concerning the energy consumption of buildings worldwide and their carbon emissions. Consequently, various governments are working to stage the development and implementation of greener building standards, and to incentivise developers who are voluntarily, adopting new sustainable measures.

Unfortunately, one major obstacle that inhibits the adoption of green building standards and practices, both at the governmental level in some countries, and particularly in the private sector, is the issue of 'cost.' Various claims are made in the marketplace concerning the degree of cost differentiation between green buildings and conventional ones, that is, those built without sustainable components.

1.1- The Research Problem

There is general agreement regarding the long-term beneficial effects of green buildings. However, there still appears to be greater concern about the cost premium of green buildings. There have been many studies conducted to investigate and identify the long-term commercial and environmental benefits of green buildings, but there has been less research undertaken, to determine just how much additional investment is actually required to design and construct a green building compared to a conventional one. As a result, the main focus of this thesis study will be on the initial investment costs at the design and construction stages of green buildings in comparison with conventional ones, rather than the long term financial benefits.

1.2- The Research Objectives

- Investigate the challenges facing the construction industry to deliver green buildings.
- Compare and contrast the key elements of green buildings that contribute to increased cost compared with conventional buildings.
- Examine the critical factors and issues influencing cost of designing and constructing green buildings.

2- Literature Review

2.1- General Overview

Population in cities is expected to double to a figure of six billion by the year 2050 according to Macomber (2003). This, in turn, will place a greater burden on the resources of the already overcrowded cities around the world. Shortages in power supply, clean water, and other necessary resources are a constant concern to governments, especially in developing countries where lack of investment capital and management capabilities exist.

In 2010, The International Energy Agency (IEA), which is an intergovernmental organization, was mandated to produce a report to assess oil supply disruption and provide information on the global energy sector. The IEA presented many interesting facts to the world's leaders. Some of these findings were that the existing buildings, of all types (residential, commercial, governmental, industrial, etc.) consume above 40% of all power consumption, globally, and at the same time, create more than a quarter of the total carbon emissions throughout the world (Howe 2010). The seriousness of these findings led many governments to take strong measures to reduce the rate of growth in power consumption, and the environmental impacts of buildings, by using more rigorous approaches in the development and adoption of green building standards for their future building projects (EPA 2013).

Water is another major challenge facing most governments. Clean water is increasingly in short supply around the world. Macomber (2013) raises the important concern that nearly half the global population lives in areas where water is scarce, or where there are limited means to collect, purify and distribute it. He highlights this issue in his article on *The big idea: Building sustainable cities*, where he states that if present trends in water consumption continue, by 2030, water demand will exceed the current supply by 40%.

2.2- Background on Green Projects

The philosophy of green buildings can be tracked back to the previous millennia when the Anasazi used local materials and passive designs to build their entire village so that all houses could receive solar heat in the winter. However in the modern age, the impetus for sustainable building designs was initially triggered as a result of the 1970 oil crisis, which forced governments to improve their energy efficiency and search for other ways to harness other forms of energy, such as from the sun and wind (EPA 2013).

Despite the existence of the concept and application of sustainability in relation to the design and construction of various dwellings, the term, "green architecture" and "green building" was first introduced by the British publication, *The Independent*, in London, in early 1990. This was followed by the Americans who used the same terms for the first time on the editor's page of *Architecture* magazine in the mid of 1990.

In 1991, The American Institute of Architect's Committee on the Environment was established, and in the same year, the first green building program began in the US, in the city of Austin. This program has been followed by many more throughout the United States. Additionally, The Green Building Committee of the American Society for Testing and Materials (ASTM) was also formed in 1991 (Kats, et al. 2003).

2.3- Current Perception of Green Buildings

In a study conducted by Annie Pearce in 2007 under the name, "Sustainable Capital Projects:

Leapfrogging the first cost barrier," Pearce explained that the greatest level of resistance to green buildings is the perception of cost that most people have. Pearce highlighted the fact that there have been many studies into the concept of cost premium of green buildings. Some of these studies have supported the 'higher cost premium' viewpoint, while others have refuted it. This has lead to a great deal of confusion among developers, government bodies and other relevant parties investigating or involved in the implementation of green initiatives.

Pearce pointed out that most of the costs involved in green projects are perceived over a two-dimensional grid as per the figure below. It appears that most decision makers will make a tradeoff between the first cost of green projects and their life cycle costs depending on the exit strategy, that is, whether they will lease the building or sell it (Pearce 2007).

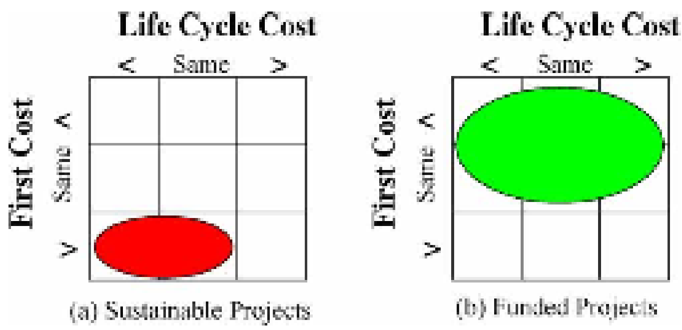

Figure 1: Expectations about sustainable project costs

The problem with the two dimensional analysis is that it is based on the general perception by most people that green buildings cost more at their beginning stages than conventional ones. Additionally, it supports the idea that green buildings will always save more on operational and maintenance costs compared to conventional constructions.

Pearce (2007) debated that to understand the costs and benefits of green buildings versus conventional buildings, an additional dimension should be added to the above grid.

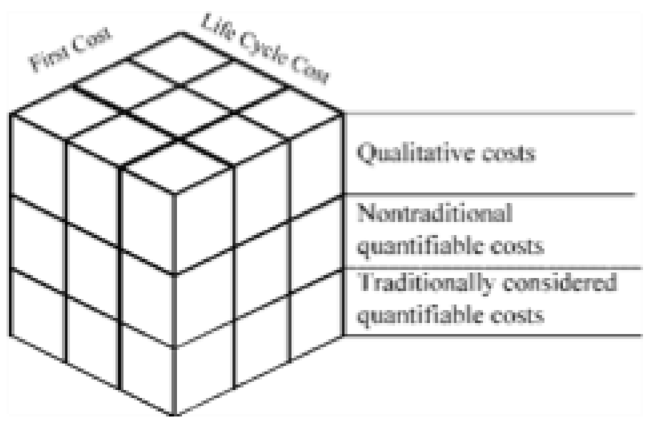

Figure 2: Revised Whole Project Cost Model

This third dimension will consist of three layers:

1- Traditionally considered quantifiable costs (these costs include such considerations as site

acquisition, design, management, maintenance and repair).
2- Non traditional quantifiable costs (these costs can be quantified but they do not necessarily affect the decision making, such as record keeping, monitoring, quality assurance, etc.).
3- Qualitative costs (these costs have a real impact but are hard to quantify because of their social values and other measurability challenges).

Despite the difficulties in quantifying the qualitative costs, this last layer is where green buildings generally outweigh conventional ones in regards to costs and benefits. This layer can be further broken down into internal costs and external costs. The internal costs can benefit the decision makers such as increased productivity of employees, improvements in the indoor air quality, and an enhanced public image. At the same time, the impact of the external costs can usually be seen on a broader scale within society such as a reduction in ecosystem degradation, biodiversity loss and global warming (Pearce 2007).

2.4- Benefits of Green Buildings

There is a considerable amount of literature that has been written on the benefits of green buildings. Not only have these included the reduction of the operational costs (tangible benefits), but also improvements in the quality of lighting, ventilation, and air within the buildings (intangible benefits).

The issue of the cost and the benefits of green buildings is not just a modern day concern. An example of this can be traced back to 1986 when the Rocky Mountain Institute (RMI) published a study (no author) where several buildings, which had made various retrofits, were examined. (Building Design & Construction 2003).

This study examined the post office in Reno that did a lighting retrofit. It found that the lighting power consumption was reduced by 69% and that the cost savings repaid the investment cost of the retrofitting within only six years. This study was not limited to old buildings only, as some newly constructed buildings showed promising results too. The Lockheed Building 157, which was completed in 1983, produced energy savings of $500,000 a year with a four-year payback.

The ING Bank Headquarters in Amsterdam, in 1987, achieved an annual energy savings of $2.6 million at the retrofit cost of only $700,000, which translated into a 3-month payback period. The design of the West Bent Mutual Insurance Company's headquarters in 1992 produced a 40% savings per square foot in electricity costs. In this study, RMI concluded that both the retrofitting of existing buildings and the construction of new ones could produce a very good payback period as a result of energy savings (Building Design & Construction 2003).

The US General Services Administration (GSA) along with many national laboratories, private companies, universities, and industries within America did a more recent study in 2013 to examine the benefits of green buildings in the US. The study included a comprehensive post-occupancy appraisal of 12 sustainable buildings (ranging from residential to commercial) to examine their level of performance from an environmental perspective, the level of satisfaction of the occupants, and their financial metrics (GSA 2013).
The 12 sustainable buildings were selected in different locations within the US to assess the performance of green buildings in different climates. All the buildings, which were selected, incorporated sustainability at the design stage and none of them were retrofitted to become

green. The performances of these buildings were compared against similar conventional buildings with the same environmental externality.

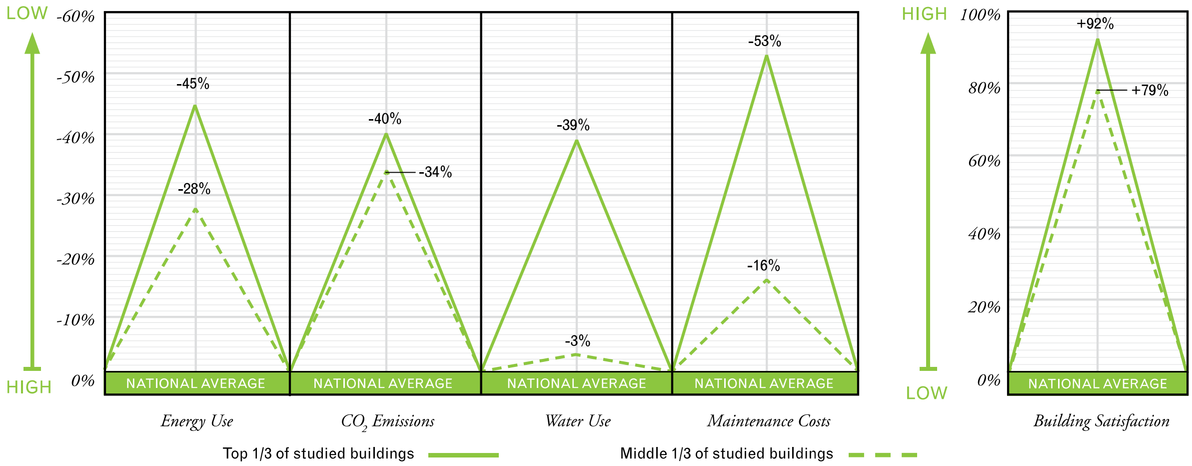

Figure 3: Performance Comparison between Green and Conventional Buildings

The key findings of that study showed how sustainable buildings outperform conventional ones in the US, with different climatic conditions. Sustainable buildings consumed 26 % less energy than the average consumption of non-sustainable buildings, and 13 % less operating costs than conventional ones. They also produced 33 % less CO2 than normal buildings, and the overall satisfaction of the occupants was 27 % higher than the average of similar conventional ones (GSA 2013).

There are many other studies, which have been carried to examine the affect of green buildings on employees' performance. One of these studies was a study by Lawrence Berkeley National Laboratory, which showed that companies in the USA could achieve a saving of up to 58 billion dollars by improving the quality of the air inside their buildings, which would in turn reduce the amount of sick leave by their employees. Furthermore the study also showed that companies in the US could also save up to $200 billion through the subsequent increase in performance of their workers (Building Design & Construction 2003).

The Heschong-Mahone group also carried out a study into the impact of day lighting on student performance. The study was done over three cities and the results showed up to a 20% higher performance rate for those students studying in environments with more daylight (Building Design & Construction 2003).

Herman-Miller performed a similar study into day lighting, and found that the productiveness of the employees rose by up to 7% after they moved to a greener building with subsequent more daylight (Building Design & Construction 2003).

2.5- The Performance of Green Buildings

Although the studies above have examined and confirmed the commercial and the environmental benefits of green buildings, a number of other studies have found that many green buildings are underperforming their design green objectives.

One of the earlier studies which scrutinized the operational performance of several green buildings in comparison with those built conventionally, in relation to the stated targets during the design stage of those green buildings, was a study conducted by Turner and Frankel in 2008. This study examined if and how green buildings outperformed conventional ones and whether green buildings meet their stated design targets when they are on operation.

The study analysed the actual measured energy performance in 121 green buildings to examine what was intended, and what the eventual outcome of these LEED projects were. It also compared these green buildings to the average energy consumption of conventional buildings within the same region.

The study concluded that overall, green buildings are outperforming the conventional ones by 25-30% in terms of energy consumption. However, more than 50% of the green projects had deviated in excess of 25% from their projection at the design phase. At the same time, 30% of the green buildings did considerably better than their intended design target.

Another a study conducted in 2012 in Canada resulted in similar findings (Newsham et al. 2012). The study was undertaken by the National Research Council (NRC) in Canada along with the Natural Resources Canada Program of Energy Research and Development (PERD), the Public Works and Government Services in Canada, the Governments of Alberta, Manitoba, Nova Scotia, New Brunswick, Ontario, and Saskatchewan; the McClung Lighting Research Foundation Inc, the University of Idaho and the Integrated Design Lab.

The study examined 24 buildings across Canada and the US; of which half of them were green and the other half were conventional. Data was collected on the physical building and on energy usage. A questionnaire was also given to the building occupants, which elicited feedback on their levels of satisfaction with their work environment and jobs, plus organisational commitment. In addition, it also asked for feedback on how they commuted to and from work, the state of their health and well-being, and their attitudes towards the environment (Newsham et al. 2012).

This study also re-analysed previously gathered data by the New Buildings Institute (NBI) in the US over the period of a year. It comprised of information from 100 North American commercial buildings that were LEED certified. Each of these sustainable buildings was matched up with a commercial, conventional building within the US that was comparable in many ways.

The study concluded that all green buildings had outperformed the conventional ones in relation to their internal environments. These included higher levels of satisfaction of the indoor environment, the thermal conditions, the air conditioning, ventilation and heating systems (HVAC) noise; and the quality of night-time sleep. The green buildings have also outperformed the conventional buildings in terms of energy and water consumption (Newsham et al. 2012).

However it is worth mentioning that many of these green buildings did not meet their expected design energy targets. Interestingly, it was also found that there was a minimal correlation between the amounts of LEED energy credits obtained during the design stage with the actual post occupancy energy performance.

This discrepancy between the design and the actual performance of the green buildings created a great deal of debate among the industry practitioners and the academic researchers. The main reason that led to this discrepancy was primarily due the occupants' operational behaviours, which could be difficult to predict. Additionally, or alternatively, the design team simply may have optimistically overestimated the amount of energy savings, which in reality was unfeasible (Newsham et al. 2012).

Another reason that was found to cause this discrepancy was the fact that those responsible for using the green technologies experienced some problems during operation. Also, in some cases, those who were responsible for operating the building did not employ the building systems as were intended (Newsham et al. 2012).

2.6- The Cost Premium of Green Buildings

There is a general agreement that green buildings are more environmental friendly than the conventional ones. Green buildings also outperform conventional buildings on many aspects such as operational cost saving, indoor air quality, lower energy and water consumption and better productivity.

However, a big debate has been going on for more than a decade between both private and public organizations regarding the cost premium green buildings require. There is a general perception that green buildings cost more than conventional ones. Nalewaik and Alexia published an article in 2008 named "Cost Benefits of Building Green" from a study they had conducted. The article described why the perception concerning the higher costs of building green used to be true:

1- Most of the technologies that were being used in earlier green buildings were new and not widely available. This limited the opportunity of any price reduction through increased supply and competition.
2- Architects who were specialized in sustainable design were also limited and so were able to charge premium rates for their services.
3- Most of contractors, especially in the early days of sustainable structures, weren't familiar with green buildings, their design or construction. Consequently, they used to add a premium to their construction cost as they perceived the construction and management process would need to be altered and the documentation level would need to be much greater and at a higher standard. This would result in an increase in administration, time, personnel, overheads and subsequent reduction in productivity. Furthermore, most of contractors (who were procured in a design and build form) added even more premium for the certification and the commissioning, as they weren't familiar on what had to be done.

However some of the methodologies, sample sources and findings of the current studies about the cost of green buildings are debatable. Also, the claims that people make about green buildings will depend on the source of information they have accessed and the studies that were used in that information. Some of those studies are also more inclusive than others regarding the costs, especially the soft costs, which will yield different outcomes. For example, various consultants and agencies such as USGBC have published many studies on green buildings over the past, but they now claim that building sustainably does not need to cost any additional premium over the amounts set for conventional buildings. However, all of those claims exclude the design and the documentation costs and mostly relies on comparing the square foot of hard costs only (Nalewaik & Alexia 2008).

On the other hand, other public and private sources have shown that a premium of 2 to 8 percent is needed for green buildings compared to conventional ones. Ultimately, in order to support or reject any of these studies, there is a very real need to conduct a proper, controlled study approach to determine the true additional cost green buildings will incur over and above conventional ones, if any. Currently, there are no data available from such a controlled study to determine what additional costs will be needed at the design stage to go green, or on green buildings at the design stage to see if there are any cost savings to be made if the design was conventional (Tatari, O and Kucukvar, M 2010).

So, until there is a data bank of academically reliable and credible studies, and their findings, the cost issue of green buildings will continue to be debated, especially when comparisons and results can be manipulated to support the views of the parties concerned, and in particular, while the data on green and conventional building costs and benefits are so varied. This concern will also continue to act as a major barrier to go green in many countries (Tatari, O and Kucukvar, M 2010).

However, in saying this, it is important to note that there appears to be a common agreement that the cost of green materials and technologies are now lower than they have previously been, and that there is a greater range available in the marketplace. In addition to that, most architects and contractors are reducing their premium as a result of becoming more familiar with the construction of green buildings. As with conventional buildings, green building costs will vary on the size, location and complexity of the projects, and the level of certification needed (Nalewaik, A and Venters, V 2008).

2.6.1- Background of Green Buildings Cost Premium

In the late 1990s the cost of green buildings was raised again as a result of introducing for the first time the implementation of the Leadership in Energy and Environmental Design (LEED) 1.0 as a pilot project and the approval of LEED 2.0 in 2000 that made it a mandatory requirement for all new projects. This raised many concerns in the real estate market on the additional costs that could result from this process (Building Design & Construction 2003).

The concerns around the possible increase in building prices considered such additional expenditure as: the fees for LEED accredited professionals, LEED certification costs, added costs for LEED improvement, payback rates and indirect cost for additional design fees.

All of these concerns caused the General Service Administration (GSA) in 1998 to conduct a study to determine whether they were valid, and if so, to what extent the cost impact would be. The investigation was assigned to HDR/Hanscomb, which then examined the LEED 1.0 against any cost premium (Building Design & Construction 2003).

HDR/Hanscomb (1998) found that 2.5 to 7.0 % additional cost premium would be needed to achieve various levels of green performance. The study also concluded that:

1- LEED 1.0 certification would add little or no increase in project costs if GSA’s design guideline were followed.

2- LEED 1.0 Gold rating for the Denver Federal Courthouse would add 7% to the project costs compared to the current scheme.
3- LEED 1.0 Silver rating for Oklahoma City Federal Building would add 2% to the project costs compared to the current scheme.
4- LEED 1.0 Silver rating for other Federal projects would add 2.5% to the project costs compared to the current scheme.

As a result of the updates of the LEED 1.0 and the introduction of LEED 2.0, GSA recognized that another study was needed. This time they contracted the Steven Winter Associates (SWA) to investigate the cost premium of the 69 LEED points, and to then use their findings to determine the additional cost that would be needed to build the new Federal Courthouse, and to retrofit a 1960s Federal Office building in accordance with the three levels of LEED (Certificate, Silver and Gold). (Building Design & Construction 2003).

The key findings of the SWA study (2000) showed that there are some LEED points that can be achieved simply with little or no cost at all (low intensity); whereas others, are more complex and need premium cost to be met (high intensity). For example, to get a point for reducing water consumption by 20%, which can be easily achieved by using low-flow faucets, is relatively inexpensive. Whereas, getting a point for reducing portable water usage for irrigation by 50% can be much more expensive, and more difficult, especially when TSE sources are not available. Using an onsite renewable energy is another example of a high intensity point that is usually an unfeasible thing to attempt (Building Design & Construction 2003).

Overall, the SWA's study (2000) indicated that a LEED Certificate could be easily achieved through using the low intensity LEED points, which shouldn't cost any premium at all. Conversely, in the case of LEED Silver or Gold, an additional cost could be expected but this could also be mitigated or avoided through well-integrated design strategies.

Parallel to the SWA study, the US Green Building Council (USGBC) in 2000 was also mandated by the US Senate Environment and Public Works Committee to investigate the concerns of the potential additional cost, which might result from enforcing the adoption of the LEED system. (Building Design & Construction 2003).

USGBC (2008) gathered all key stockholders from public officials, real estate practitioners, academicians, and USGBC members to participate in the preparation of making the business case for high performance buildings. This report concluded the following facts:

1- Many green buildings don't cost any additional cost compared to conventional ones, and in some cases, they cost less due to the downsizing of the more costly mechanical, electrical, and structural systems as a result of the projected reduction in power and water consumption. The key success factor is the successful design integration.
2- A saving of 50% in energy consumption can be achieved through a successful design integration, site orientation, energy saving technologies, light reflective materials, natural daylight and ventilation, and downsized HVAC and other equipment.

2.6.2- Cost Determining Techniques

There are many strategies to achieve certification points at minimum cost. Some points will cost nothing to be achieved while others will be more expensive. Therefore, the designers will need to carefully consider each point in terms of cost burden. Another strategy would be to invest in multitask technologies which would obtain several points instead of a single one.

In order to determine valid views of the actual cost premium of green buildings, 'Artificial Intelligence' techniques are needed to help decision makers to select the best green initiatives. There are a few decision models used to determine the cost premium of green buildings. One of these models was developed by Castrolacouture et al. (2009) which suggested the use of a mixed integer optimization model which maximizes LEED credits when considering design and budget constraints.

Another model was developed by Wang et al. (2005) called an 'Object-oriented Framework.' It aimed to address specific problem areas related to green building design optimization. This framework uses multi objective, genetic, algorithms to explore the trade off between life cycle cost and life cycle environmental impacts in green building design. Wang et al. (2005) also developed another model to optimize the building shapes using the genetic algorithms by using life cycle cost and life environmental impact as two objective functions for green performance evaluation.

Another useful study was conducted by Tatari, Omar, Kucukvar, and Murat (2010) who introduced a new model called 'Artificial Neural Network' (ANN) in their published study called, "Cost premium prediction of certified green buildings: A neural network approach," in 2010. It was the first time that green buildings had been examined by ANN to determine the cost premium. The Artificial Neural Network model was used because of its parallel processing and fast response; its tolerance for fault; and its better classification and prediction capability than traditional statistical methods. The Artificial Neural Network model had been used previously, along with other models, on conventional buildings. For example, Gunaydin and Dogan (2004) developed a neural network model for 30 residential building projects to estimate cost per square meters. Kim et al. (2004) used three different prediction models; neural network, regression analysis, and case-based reasoning, to predict the cost of 530 buildings in Korea. In another study, Kim et al. (2004) provided hybrid models of neural networks and genetic algorithms for preliminary costs estimation of 498 residential buildings. Emsley et al. (2002) developed an ANN model to predict building cost by utilizing project strategic variables, site related variables, and design related variables. Attalla and Hegazy (2003) used ANN modeling and statistical analysis for determining the cost deviation of a reconstruction project. Apart from ANN, some studies have utilized multiple regression analysis for cost prediction. For instance, Stoy et al. (2008) used regression analysis for determining the cost drivers of the 70 residential building properties.

2.7- Cost Comparison of Green Buildings

There have been many studies carried out in relation to the various cost differences between green buildings and conventional ones. Other studies have looked specifically at how the different levels of certification affect the cost of green buildings.

2.7.1- Cost Premium Compared to Conventional Buildings

One of the early reliable studies on comparing the cost premium of green buildings with conventional ones was a study conducted by Anne Sprunt Crawley and Beverly Dyer on behalf of the US Department of Energy. What was unique about this study was the fact that they managed to examine the cost of a hypothetical, two storied building of 20,000 sq ft without any sustainability requirement (conventional), which was estimated to be $2.4 million. They were then were able to modified these calculations by including sustainability requirements using certain modeling software plus vendor quotes. The additional cost premium was found to be $47,210 over the base case construction costs, which is less than 2% cost premium.

There was a similar finding by another study done by Kats, et al. in 2003. This study had gathered a considerable amount of data and had analysed this in relation to the expenditure used to build green buildings and the subsequent, financially quantifiable, benefits. Information was gathered from several dozen architectural designers and representatives of the green building industry within the state of California. They provided the analysis team with their costs on 33 green buildings in the area. Interestingly, these green building's average premium was below 2%, which is significantly lower than is generally believed.

What was apparent from the data gathered, was that the higher costs involved in green buildings came from the additional time spent by architects and engineers to ensure best practices concerning sustainability that were incorporated during the design phase.

Another interesting study was conducted by the Davis Langdon Company in 2007. Two hundred and twenty one buildings (83 LEED and 138 non LEED) were analysed and regularized to take into account variations in dates and locations so that the comparison could be more consistent. However, only three types of buildings were examined:

1. Academic buildings
2. Laboratory buildings
3. Library buildings

In their study, they used three criteria to examine green building costs: the incorporation of individual, sustainable components; the comparison of the costs of similar buildings built conventionally; and the actual green building costs as opposed to their original budgets. Furthermore, it is worth mentioning that all of the LEED buildings were Certified, Silver, or Gold LEED; no LEED Platinum certified buildings were included.

2.7.1a Cost Analysis of Academic Buildings

Sixty academic buildings were analysed. Of these, 17 sought and received LEED certification and 43 did not. Only academic buildings on university and college campuses in the US were considered. The architecture of these buildings was varied, but the researchers focused on classrooms, computer labs, and faculty office buildings. Those that achieved a higher LEED level did so in the areas of internal environments, efficiencies in energy and site features.

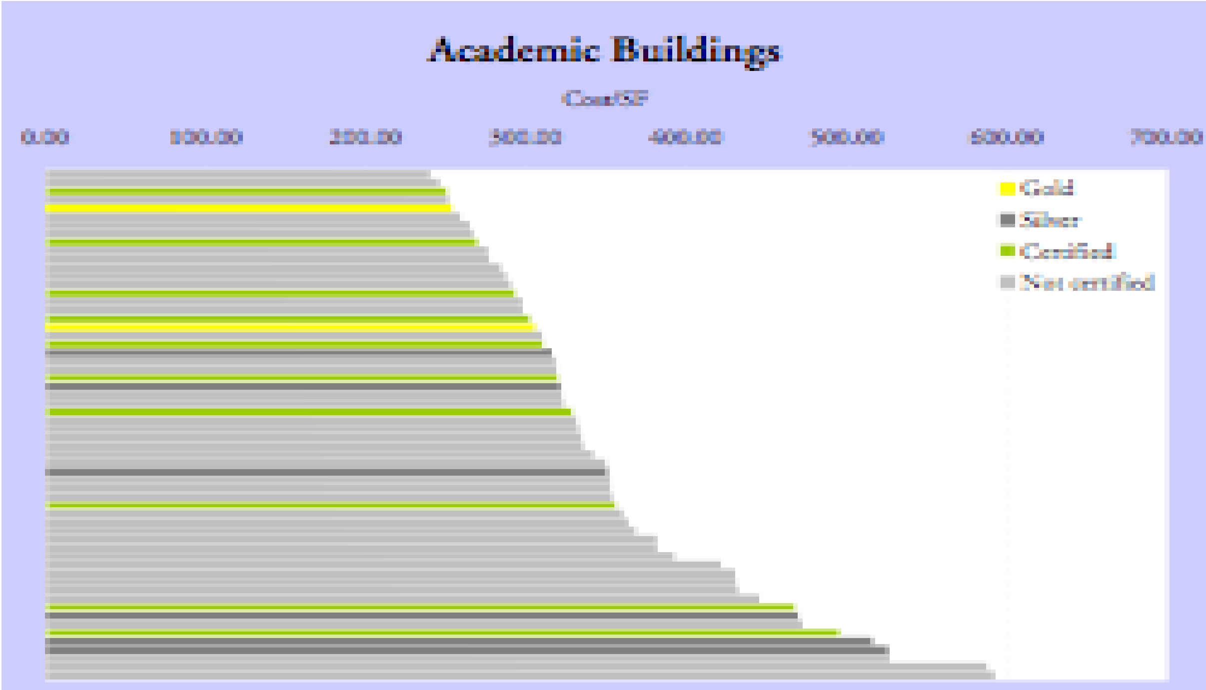

Figure 4: Cost Analysis of Academic Buildings

What was especially significant about this study was that both the LEED seeking and non-LEED seeking academic buildings were spread across the population with no real variation between the two in cost. Also, the buildings with a LEED Silver rating were predominantly in the higher cost bracket, and the Gold towards the lower end when compared with each other and across the overall population. Unfortunately the Gold sample was too small to exact solid conclusions, but what was apparent was that the costs of the Gold buildings were able to be kept down through employing simple sustainable methods as opposed to using additional green technologies (Davis Langdon 2007).

2.7.1b Cost Analysis of Laboratory Buildings

Seventy laboratories also underwent an analysis; of these, 26 sought and received LEED certification and 44 did not. These included laboratories across a range of disciplines in the science field, involved in teaching, research and production. The laboratories were located in wet and dry science buildings. Those that had received LEED certification achieved a high score in Energy efficiency, which was largely due to the design of buildings with laboratories. These buildings usually have strong and efficient mechanical systems.

As with the academic buildings, there was no noteworthy difference between those laboratories that had sought LEED certification, and those that had not, in terms of the average costs per square foot. What was significant was that the LEED seeking laboratories were spread across the study population, even though there was a reasonably wide, standard deviation in price amongst all the laboratories. With this group of buildings, the Silver ones were distributed across 75% of the range but, again, no conclusive analysis could be postured on the Gold laboratories due to the limited sample size (Davis Langdon 2007).

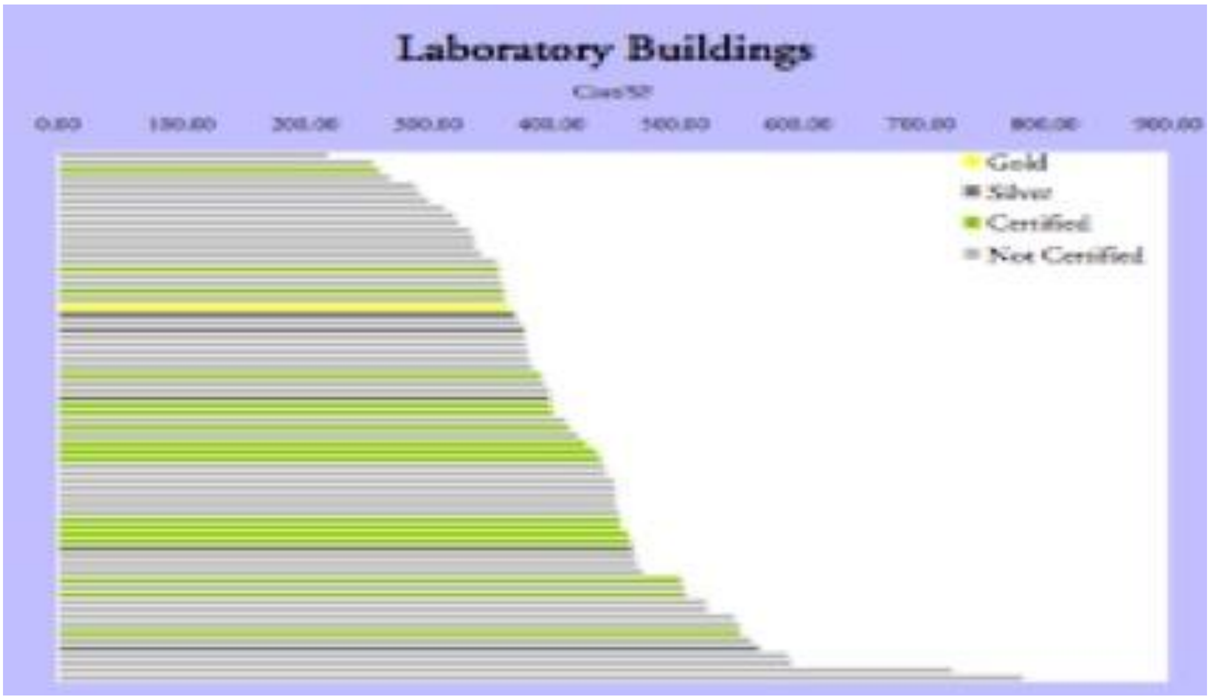

Figure 5: Cost Analysis of Laboratory Buildings

2.7.1c Cost Analysis of Library Buildings

Fifty-seven libraries were also analysed as part of this study. These included different types of library buildings, not just those found on higher education campuses. Additionally, branch and community libraries were included as well as the main public ones. Those libraries that were LEED certified scored higher with regards to the indoor environmental quality. However, on pricing, they were spread across the population in a similar fashion to the non-certified library buildings. Several of the LEED projects were even found in the lowest cost bracket, which means that LEED certified libraries are no more expensive than non-LEED ones. This may contribute to the higher green versus non-green ratio, than can be found in the other two building groups. However, another contributing factor is that there has been a growing trend towards this type of building, going green, especially new library projects (Davis Langdon 2007).

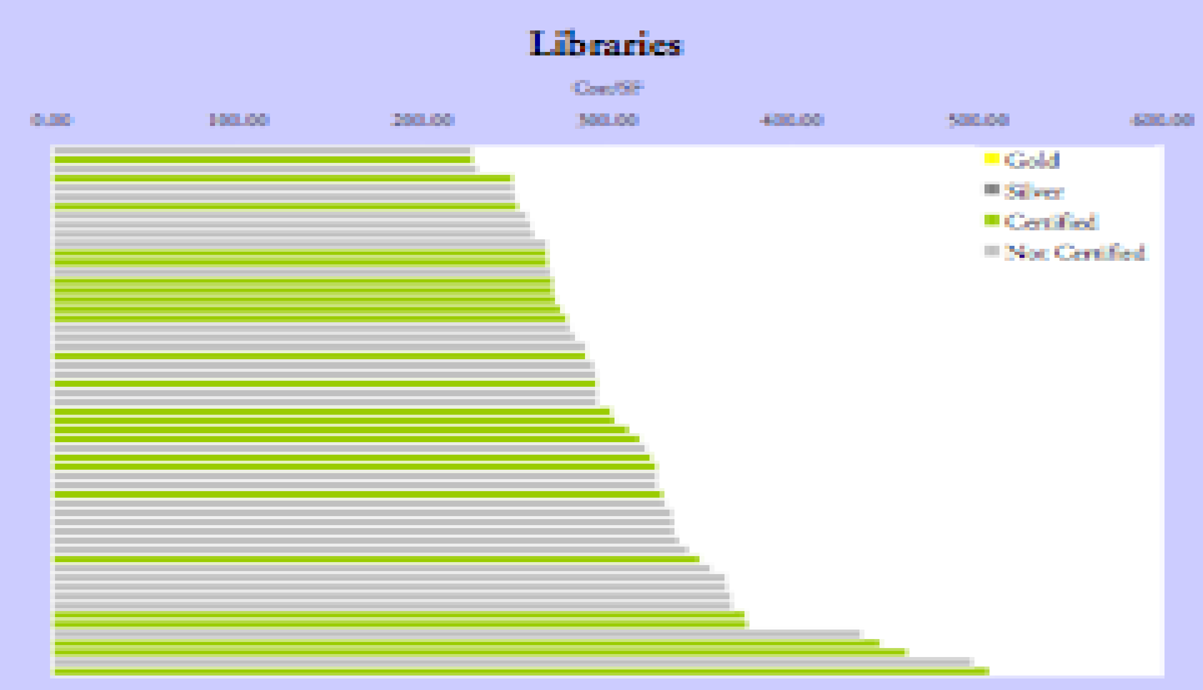

Figure 6: Cost Analysis of Library Buildings

As can be seen from this study, green buildings are like conventional ones in that the cost is predominantly determined by the design of the project itself, and the clients' requirements. Overall, from the cost comparisons between the building projects that sought LEED certification and those that didn't, the study was able to draw four main conclusions:

1. The cost range of these buildings is widespread, even amongst the same building type.
2. The differences in the building costs are largely due to the program type.
3. Green buildings can be found anywhere from low to high cost construction projects.
4. Non-green buildings can be found anywhere from low to high cost construction projects.

In drawing these conclusions, it is important to remember that there is an equally wide range of cost variation amongst building projects in the marketplace, without even including the issue of green versus non-green designs. This, no doubt, was a contributing factor in the lack of important statistical differences between the buildings seeking LEED certificates, and those that didn't. In addition to this, comparisons across buildings, or sets of buildings, based on average cost per square foot, are generally not so accurate, as the range can be so wide that it skews the true average figure (Davis Langdon 2007).

2.7.2- Cost Premium of Different Green Certification Levels

The early study done by the Steven Winter Associates (SWA) (2000) was mainly intended to determine the cost premium of green buildings compared to conventional ones. However, an interesting outcome was also highlighted according to the study. It was found that the LEED Certificate could be achieved at no additional cost compared to the other levels of LEED (Silver, Gold and Platinum), which could increase the project cost by 2% to 7% depending on the design (Building Design & Construction 2003).

There was another study carried out by USBG (2002) that intended to compare the cost premium of different LEED certification levels. The study found some interesting results when comparing the 26 LEED 1.0 and LEED 2.0 projects. The cost of each building per square foot varied from $13 to $425.

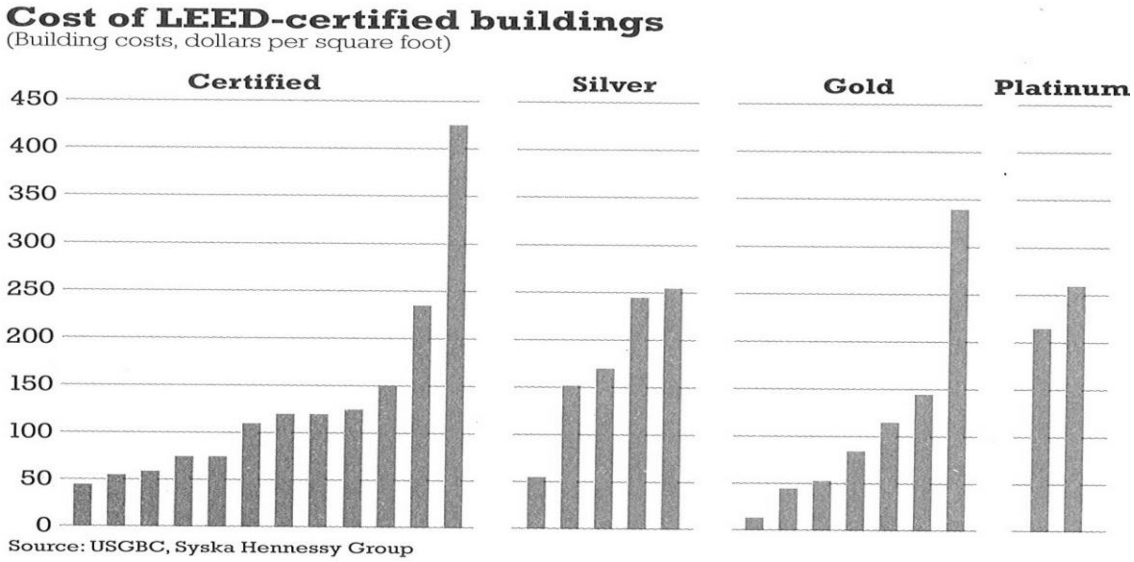

Figure 7: Cost of LEED Certified Buildings

The USBG study found that there was no significant correlation between cost and LEED ratings. Two LEED Platinum buildings cost $215 and $260 per square foot where some lesser LEED rating buildings cost up to $340 per square foot (see the Gold LEED bar chart). Two LEED silver buildings cost $245 and $255 per square foot respectively, while two LEED certified buildings cost $235 and $425 per square foot respectively. This can be simply explained, by identifying that different building types can cost more per square foot to construct than others (Building Design & Construction 2003).

Similar views were also shared by Gregory Kats in 2003, (a founding principle of Capital E, Washington D.C.) for the California task force who analyzed 33 certified or pre-certified buildings, nationally. These included 25 office, and 8 school, buildings that had been, or were due to be completed from 1995 to 2004. The selection of these projects was determined by the availability of reliable data concerning the actual costs of each building's design, in green terms, and conventionally.

Although a large number of these buildings hadn't undergone the certification process through USGBC, they had been given an estimated LEED level based on a detailed and thorough assessment by the client or design team. These estimations are considered to be close to what is predicted to be their final level LEED certificate (Kats, et al. 2003).

Even though the number of buildings studied was small in comparison to research studies, the analysis of the data provided a deeper understanding of the cost range involved in green buildings. In the figure below, the average cost premium is around 2%. The Bronze rated buildings had a lower cost premium at 1%, as did the Gold level buildings at 1.8%. Silver rated buildings were slightly higher than the average at 2.1%, whereas the cost premium rose dramatically to 6.5% for the Platinum level buildings (Kats, et al. 2003).

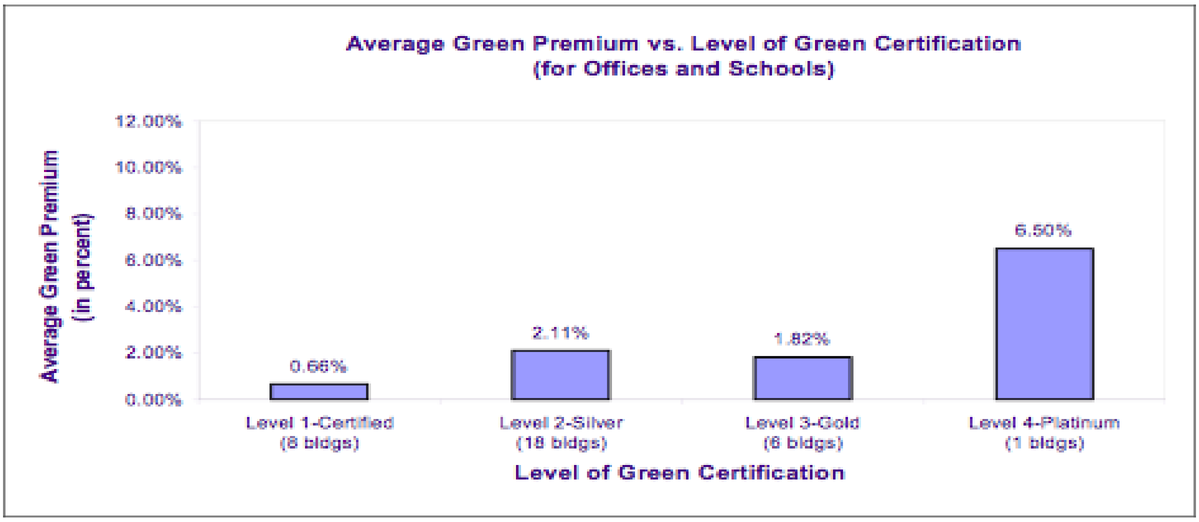

Figure 8: Average Green Premium vs. Level of Green Certification (Offices and Schools)

Although there is a growing body of evidence that the cost of green buildings lessens with time, the data did not give a clear indication of this. In saying that, the green premium was the lowest for the buildings that had only just been completed, but at the same time, the green premium projections for projects due to be completed in the following two years (2003–2004) were higher (Kats, et al. 2003).

The reason for this was evident in the data, in that the cost projections for the 2003-2004 constructions were set at the conservative end of the green premium scale. Once these buildings were completed, then it was anticipated that these figures would drop to a more realistic level. Another important consideration concerning these projected costs was the fact that the data collected came from designers with varying degrees of experience in designing green buildings. For some, it would have been their first attempt and so their green premium projections would have reflected this, while others, who were more experienced, would have set more accurate premiums (Kats, et al. 2003).

Another interesting anomaly reflected in the data was the different cost levels given for the LEED Gold buildings as opposed to the cost levels of the Silver ones. It would be totally feasible to expect the reverse, as the higher rating would have greater requirements to meet.

This result can be attributed to the limited number of buildings in the data set. The green premium shown for the Gold level is the average of only six buildings. Consequently, as more data for this category is added, this could rise, given the higher standards to meet. However, the data did reveal that Gold level buildings can be built at reasonable cost premiums and therefore can be a realistic target for green buildings.

The conclusion of this study showed that overall, the costs involved in the construction of green buildings are currently higher than when building conventional ones. However, that cost is smaller than what most investors assume (Kats, et al. 2003). The cost of green buildings is decreasing with time, as the knowledge of developing these constructions is increasing amongst developers, consultants and contractors.

Another study done by KEMA Xenergy (2002) reviewed 50 green buildings and found that the premium for green buildings had fallen sharply regardless of the earlier estimates which showed a premium of 2 to 5 % for LEED certified buildings, and 10 % for Silver, Gold and Platinum. For example, the data from Block 225 of the Capitol Area East End Project in Sacramento achieved LEED gold rating without any additional cost over its original base budget. Other data from Seattle had shown a premium of only 1.7% for all the municipal projects (Building Design & Construction 2003).

2.8- Soft Costs of Green Buildings

The design of green buildings is generally more expensive than the design of conventional buildings. This is due to the fact that green building designs are usually more complex than conventional ones. In the design of a green building, a holistic and integrated design process is being used right at the start of the project, as green buildings have many unique design features not typically found in conventional buildings and require deeper integration (Kibert, 2008).

In another study by Yudelson in the same year (2008), he divided green building designs into three categories, namely: indoor lighting, building materials, and layout. Yudelson elaborated that in a green building, the lighting design integrates low-energy lighting fixtures with natural lighting through strategic window installation and usage of energy- efficient fluorescent lighting.

Environmentally friendly building materials, such as recyclable bamboo flooring, as well as toxic-free materials, such as formaldehyde-free cabinets and non-toxic paint, are used in green buildings to ensure that they are sustainable. Building layout plays a significant role in ameliorating energy efficiency of the building. Green buildings also take advantage of natural ventilation through the building’s orientation (Bon-Gang Hwang and Jac See Tan, 2010).

Another factor, which increases the soft cost of green buildings, is the fact that most of the certification bodies, such as LEED, require a commissioning of the building as a prerequisite for certification. This increases the soft costs of the project as a third party engineer will be required to inspect the building systems to ensure that they preform as per the design specifications. These systems include mechanical, electrical, plumbing, controls, fire management, audiovisual installations and elevators.

The process also includes proper documentation, testing and inspection at startup, correction of deficiencies, performance verification, reporting, operator training, and supply of operation and maintenance manuals. All of these will lead to an increase in the green project soft cost as well (Nalewaik, A and Venters, V 2008).

These are just some of the reasons that the design of green buildings usually cost more than the design of conventional ones.

2.9- Factors that could Influence the Cost of Green Buildings

The study done by KEMA Xenergy (2002) where the 50 green buildings were reviewed, also found that subsequent government green projects had dropped greatly mainly due to the start up costs, training and research. The study concluded five management reasons that could lead to increased green project costs:

1- Lack of a clear green design goal, which is a crucial part in controlling any green project cost, and should be defined before releasing the initial design RFP.
2- Lack of projected planning. Green designs may be incorporated at the mid project stage rather than at the start which could result in the need to redo the design work and therefore increase the design cost.
3- Lack of a single point of responsibility during the LEED process.
4- Lack of knowledge of LEED.
5- Lack of time to research green materials and technology options. This is a very important consideration to keep in mind as green products and technologies are coming onto the markets on a weekly basis.

In another study carried out by Bon-Gang Hwang and Jac See Tan in 2012, under the name "Green Building Project Management: Obstacles and Solutions for Sustainable Development," the authors conducted a survey of 101 managers and professionals listed under the BCA's Certified Green GMM and GMP Scheme in Singapore to examine the factors which could affect the cost of green buildings and their responses were as follows:

No	Obstacles	Frequency	Percentage (%)
1	High cost premium of green building project	31	100.0
2	Lack of communication and interest amongst project team members	26	83.9
3	Lack of required expertise in green building	0	0.0
4	Lack of knowledge regarding green building principles	0	0.0
5	Lack of management and time to implement green construction practices	8	25.8
6	Lack of expressed interest from client and market demand	16	51.6
7	Lack of expressed interest from other project team members	12	38.7
8	Resistance to change from conventional to green practices by company's employees	11	35.5
9	Lack of government's support (e.g. incentives) for sustainable construction	0	0.0
10	Green building practices are costly to implement	24	77.4
11	Lack of information regarding green products and building systems	9	0.0
12	Lack of credible research on the benefits of green buildings	21	67.7
13	Complex codes and regulations on green building and sustainable construction	7	22.6

Table 1: Obstacles encountered during green building project management

According to the survey results, and as can be seen underlined in the above Table, the top Six obstacles encountered by professionals and managers when managing a green building project are:

(1) The high premium cost associated with green building construction; for example, compressed wheat board, which is a green substitute for plywood, costs about *10 times* more than ordinary plywood.
(2) The lack of communication and interest between project members.

(3) The lack of expressed interest from clients or market demand.
(4) The lack of credible research on the benefits of green buildings.
(5) The lack of Green Product Information: the lack of such information makes developers use consultants who are specialized in green products and building systems, but usually at a premium fee which therefore increases the project cost.
(6) The high cost and complexity of Green Building compliance. Green building practices are costly to implement and Green Building codes and regulations are becoming more complicated, thus causing difficulties for developers when evaluating the cost involved in the compliance of such codes.

Surprisingly, none of the respondents in the survey felt that there was a lack of expertise and knowledge in green buildings and their principles. This could indicate that there are many good consultancy and services provided in Singapore to assist in green building construction.
Furthermore, none of them felt that there was a lack of governmental support for sustainable construction, which could be due to the tremendous effort that the government has put into actively promoting green building and sustainable development (Bon-Gang Hwang and Jac See Tan 2012).

Another far eastern study conducted by Tam, Hao and Zeng (2011) was published under the title of, "What affects implementation of green buildings? Empirical Study in Hong Kong." The authors identified the following factors which increase the cost of green buildings in Hong Kong:

1- The use of energy efficient systems is one of major cost elements in green projects in Hong Kong.
2- The lack of green materials locally is another major cost driver as some of these materials are imported and therefore the transportation cost escalates the price.
3- The increase in the preparation and processing involved in the production of local green materials generally make them more expensive than conventional materials. .
4- The higher level requirements of green designs also raises the cost of green projects as they require more analysis and in depth understanding of site parameters such as orientation, weather patterns, and temperature; all of which can improve the performance of green buildings.

The study by Tam, Hao and Zeng (2011) also addressed the cause of the cost premium of green buildings from a management perspective:

1- The incomplete integration among project team members, which could be caused by the lack of a clear green design goal and the absence of a single point of responsibility.
2- The lack of knowledge and experience in developing green buildings.
3- Insufficient time and funding for searching for new green products and technologies.

Another study by Tatari, Omar, Kucukvar, and Murat (2010) who introduced the new model called Artificial Neural Network (ANN), also examined possible factors that can influence the cost of green buildings. They selected 74 LEED-NC, version 2.2, certified buildings to study using the ANN model in order to analyze the cost premium of different LEED categories. These categories included Sustainable Sites (SS), Water Efficiency (WE), Energy and Atmosphere (EA), Material and Resources (MR), Indoor Environmental Quality (IEQ), Innovation and Design Processes (ID) and Building Grade (BG). The cost premium assumptions were based on the study that was conducted by Kats (see the below table):

The data description of the 74 LEED-NC certified buildings in USA.

Description	Mean	Minimum	Maximum	Std. deviation	Output/input
SS point	8.12	3	12	2.25	Input
WE point	3.21	1	5	1.21	Input
EA point	6.82	1	17	4.37	Input
MR point	5.47	1	11	1.58	Input
EQ point	9.08	4	14	2.44	Input
ID point	4.12	1	5	1.09	Input
Building grade	2.37	1	5	1.00	Input
Year built	–	2000	2008	–	–
Premium cost ($/sf)	4.98	0.31	18.33	4.06	Output

Table 2: The data description of the 74 LEED-NC certified buildings in USA

These categories were used as inputs in the modeling process (as shown in the table above) and the premium cost was entered as an output variable for the ANN model.

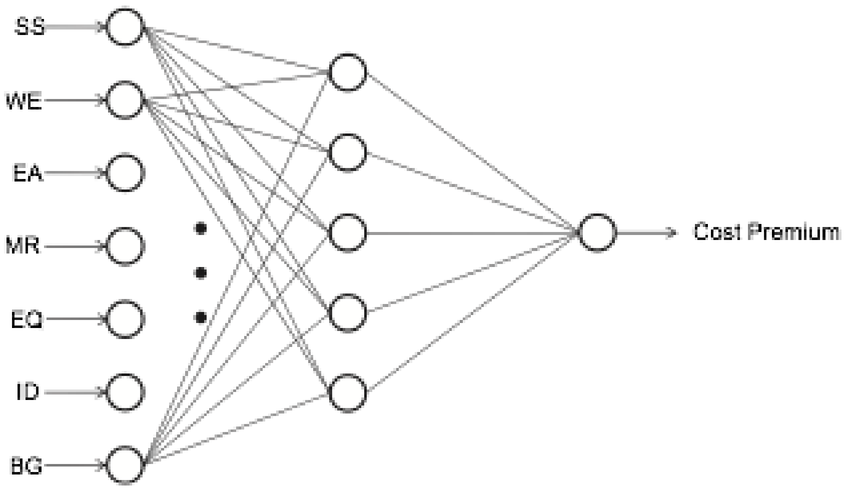

Figure 9: Architecture for the best performing ANN model

The findings of this study showed that Sustainable Sites, Energy and Atmosphere, and Building Grade were the main cost premium causes (Tatari, Omar, Kucukvar, & Murat 2010).

In summarizing, it is clear from this literature review that there are similarities and differences between the various studies that have been conducted around the issue of green building costs and cost premiums, along with comparisons with conventional building costs. Overall, the results suggest that there are some cost factors that are more localized to a certain part or parts of the world, whereas they may not be as relevant elsewhere. For example, the knowledge, access, and use of green materials and green technologies seem to present a greater challenge in the Far East in comparison with the US market, which doesn't seem to suffer from this issue. At the same time, the studies identified some common factors that have an influence on green building costs. These factors, which can be considered as more general challenges across the global green building industry, are related primarily to the management process of green buildings. For example, the lack of integration in the design stage seems to be a common challenge among many green building developers, globally.

3- Conceptual Framework

3.1- Introduction

According to Miles and Huberman (1994), they defined a conceptual framework as a visual or written product, one that “explains, either graphically or in narrative form, the main things to be studied, the key factors, concepts, or variables and the presumed relationships among them”. Therefore, the conceptual framework would reflect the system of concepts, assumptions, expectations, beliefs, and theories that support your research.
The conceptual framework aims to address what is the thesis planning to study and why. It also would help to assess and refine the research goals, develop realistic and relevant research questions, select appropriate methods, and identify potential validity threats to your conclusions.

3.2- Study Motivation

The intention of this conceptual framework is to define the specific variables which are according to the literature review if not managed properly could lead to add a cost premium to any green building with a gravity which depends on the complexity of the project and the level of green objectives it aims to achieve.

These specific variables should not to be confused with the generic factors, which could cause any project (green or conventional) to go over budget. For example, Architectural features, Specification and timeframe. These specific factors are more related to green projects and they shall be looked at as additional factors on top of the generic ones.

From the literature reviews, six main factors could lead to a cost premium if they weren’t managed probably. These factors are:

1- Early Definition of Green objectives
2- Early Design Integration
3- Procurement Method
4- Green Products Availability and Cost
5- Experience Contractor
6- Experienced Designer

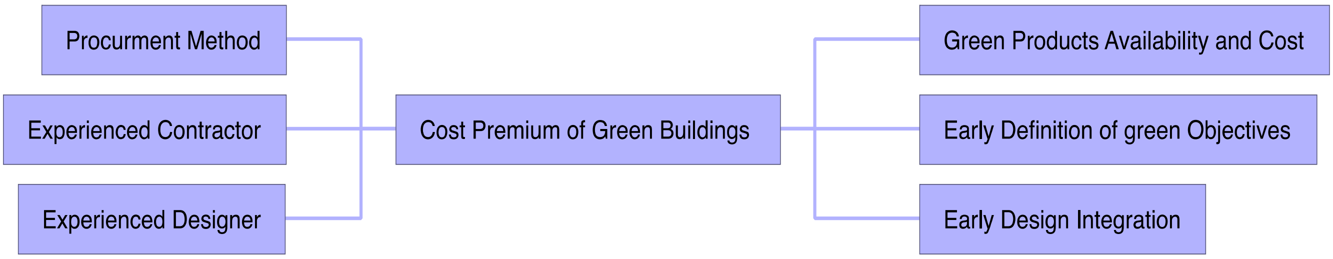

Figure 10: Conceptual Framework Model

This conceptual framework will be used to test the cost premium of green buildings in the UAE and whether there are any additional variables not mentioned in the literature reviews, which could alter the above conceptual framework to suit the UAE market.

4- Sustainability in the UAE

The UAE climate is warm, dry, and sunny during the winter months. The summer climate is also sunny, but hot and humid. The average daytime temperature in the winter is 26°C, and nighttime temperatures are generally in the range of 12-15°C along the coast, but this drops to less than 5°C in the mountains and inner desert regions. Temperatures often reach the mid-40s in the summer, although these can even go higher, further inland. Coastal areas generally experience an average humidity rate of between 50%-60%, but during the summer and autumn months, this can exceed 90% (Szabo 2011). The humidity levels inland are generally lower. Humid southeasterly winds blow along the coast in summer and local northwesterly (Shamal) winds, commonly occur in the winter.

Sparse and intermittent rainfall occurs during the winter months, often in the form of short, sharp bursts, which usually run off rapidly down the Hajar Mountains into dry riverbeds (wadis) or stony plains. Localized thunderstorms, do sporadically occur in the months of summer, but tend to be centred around the mountains in the south and east of the country. Sufficient rain can fall to cause flash flooding. However, the average annual rainfall is usually around 120mm in the coastal regions but this can vary drastically from year to year, from as little as 30 mm, to 350 mm, depending on the location (Szabo 2011).

Oil has produced dramatic changes in the UAE since it began to be commercially exploited in 1962. Not only did the wealth of the country increase to where its GDP has now placed it up with the world's wealthiest nations, but so did the need for foreign workers. As a result, the population has risen by 40 fold since the 1968 census (Szabo 2011). Figure 11 (on the next page) shows the exponential growth in population in relation to a similar pattern for the country's GDP, albeit at a lower rate of incline.

Energy demand fluctuates dramatically throughout the year, and as a result, the UAE has one of the most varied, demand curves in the world, on an annual basis. This presents a common challenge for all the UAE utility authorities. As the heat in the summer months climbs, so does the energy demands which can be in excess of 92% of the country's installed generation capacity. In contrast, this can drop to around a third of the energy that the UAE can generate, in the cooler evenings, during winter. Generally, the levels of operation of the power plants during the winter months, are dictated to by requirements regarding the ongoing production of potable water (UAE embassy WDC 2013)

Water demand in the UAE continues to grow, irrespective of the limited resources in the country, and the region. This is a serious issue, especially given the estimation that water availability, per capita, within the MENA region will shrink by 50% by the year 2050. The resulting consequences will be critical, given the current over-demands on the region's aquifers and natural hydrological systems (World Bank 2007). In one of their presentations (2009), the Environment Agency in Abu Dhabi (EAD), reported that groundwater (72%), and desalination (21%), were the main sources of water used in the UAE, with retreated water making up the last 7%. Surface water resources in the country are virtually nonexistent (Szabo 2011).

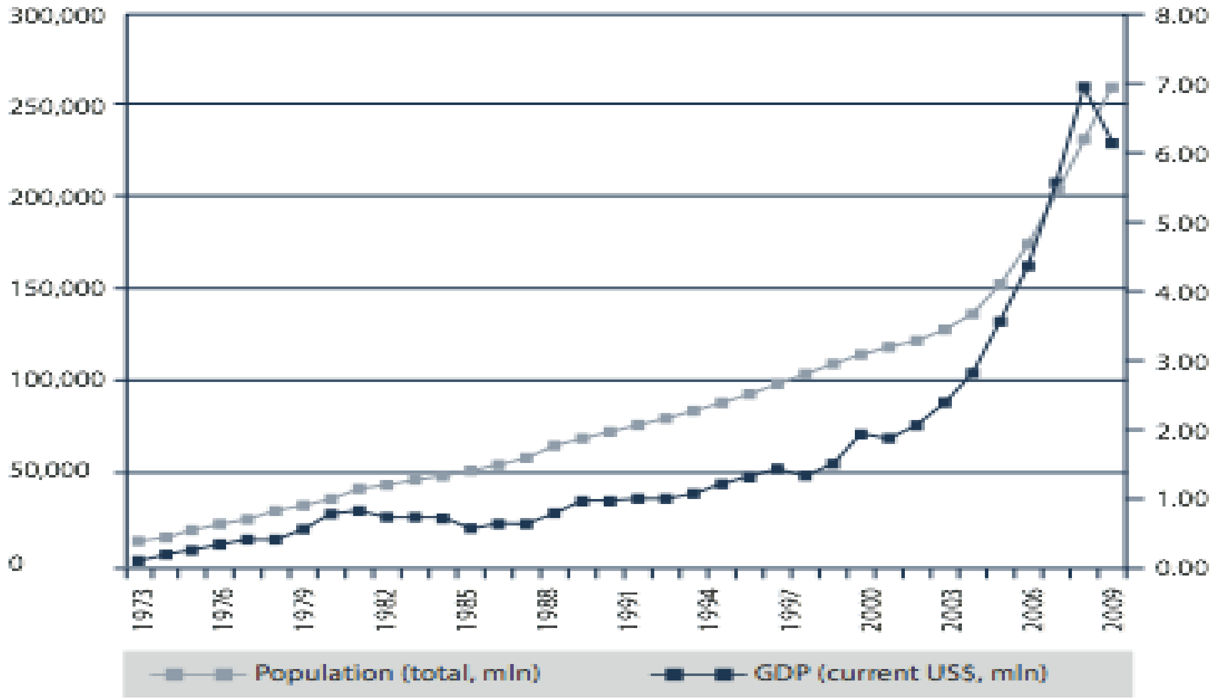

Figure 11: Calculation based on World Bank Indicators

All of these concerns have put pressure on the UAE government to address these challenges with strong and far-reaching sustainable measures. This action will profit the UAE, not just environmentally, but also commercially, in the form of billions of dirhams worth of savings made in not having to continuously expand its desalination plants and power substations. In acknowledging all of these problems, there is still a substantial amount of work to be done at a federal level, as the UAE is still one of the top countries which subsidize power and water heavily. These subsidies discourage people and private companies to behave sustainably, towards the end of becoming eco-friendly, and will have a drastic impact on the country especially with the exponential increase in population.

However, on a state level, there has been more firm initiatives to address the growing power and water demand issues. Abu Dhabi is one of these emirates, which has set KPIs for transforming the state to be one of the most sustainable cities in the world. One of these initiatives was the establishment of the Abu Dhabi Urban Planning Council (UPC), which was set up as a result of a decree by the Amiri (Decree 23: 2007). The UPC was given the responsibility for all future urban environments within Abu Dhabi, and was tasked with job of being both the expert and authority on the visionary ‘Abu Dhabi 2030 Urban Structure Framework Plan.’ This plan ensures that various factors are considered in urban developments such as sustainability, infrastructure capacity, community planning and quality of life. The UPC also ensures that in any urban planning, both in existing and new areas, best practice is employed (UPC 2013).

The purpose of establishing the UPC was to evolve the building codes to become more sustainable and adaptive for conserving resources. In other words, it has become an authority, which ensures that the adoption of sustainable KPIs are part of the design, construction, and operations of any project within the emirate. The UPC grants planning permission for any new developments by using a highly consistent development review process. This assists them in making the best development decisions, and applying strict regulatory controls for developers across all their projects. This will help the emirate to make the most of the current climate of economic and cultural growth (UPC 2013). Therefore, the Abu Dhabi Urban Planning Council is engaged in two primary activities:

1. Reviewing and approving new developments.
2. Creating infrastructure plans that set out the rules and guidelines to which developers must adhere.

The UPC (2013) describes the aims of the reviewing process:

1. Provides developers with information and direction to improve overall integration with the surrounding area.
2. Provides the UPC with all the required data so that well informed decisions can be made regarding development applications.
3. Ensures a transparent, consistent system is used for all development reviews.

5- Methodology

In this thesis, two methods will be used to examine the issue of green building cost premiums in the UAE:

Method 1: Cost Comparative Approach

Two recent green buildings will be compared with two similar conventional buildings in terms of construction cost per square meter at a shell and core level. The comparison will include: HVAC (but will exclude air conditioning as the green buildings are connected to a centralized district cooling plant), completion of associated public spaces, and above or underground parking spaces. This comparative study will exclude the design fee, land price and finishing items.

Method 2: Case Study – Masdar Headquarters Building

Interviews with all key stakeholders of the Masdar Headquarters Building project (which was used in the case study) will be conducted to discuss the methodology that was adopted in order to complete this green project successfully. The use of the interview approach will also address the different cost elements of green buildings and will identify the practices that have been adopted to ensure the cost effectiveness of green buildings.

Prior to that, a full description of the Masdar Headquarters Building will also be discussed and all the green objectives that have been achieved will be outlined.

5.1- Method One: Cost comparison

This section will compare the project cost of two green buildings and two conventional buildings in the UAE. These buildings are:

1- Siemens Headquarters Building (Green)
2- Masdar Headquarters Building (Green)
3- Landmark Tower (Conventional)
4- Tamweel Building (conventional)

Cost data were gathered from previous market studies conducted by Masdar's internal team (Secondary Data). The reason for selecting secondary data was that it saves valuable time, which can then be used instead to gather more data. Even more importantly, it provides researchers with access to more extensive and higher quality databases where they can find data in greater depth and amount, especially quantitative data. This data exceeds what they singlehandedly could collect themselves. Additionally, it enables the researcher to review information from past studies and developments, which they could not gain by conducting a new survey (Secondary Data 2010).

It is also worth mentioning that the contractors for both the green buildings were procured as a 'Design and Build' after the concept design was developed whereas the contractor for the other two conventional buildings were procured traditionally (Design-Bid-Build).

5.1.1. Findings

Both Siemens HQ, and the Masdar HQ projects had set an estimated budget of AED 7,000 per m² in order to be comparative with construction cost rates used for the conventional buildings. These usually range between AED 4,500 to AED 9,500 per m² (as per the 2009/2010 rates), depending on their grade.

In the following table, the projected versus the actual costs have been listed for both the green buildings and the conventional ones.

	Siemens HQ Building	**Masdar HQ Building**	**Landmark Tower**	**Tamweel Building**
Location	Masdar City, Abu Dhabi	Masdar City, Abu Dhabi	Corniche, Abu Dhabi	JLT, Dubai
Gross Floor Area (GFA) - in m²	22,176	32,570	82,643	79,838
Actual Project Cost (AED)	136,900,000	199,816,950	510,000,000	491,323,052
Budget Cost / GFA (AED/m²)	7,000	7,000	7,500	7,500
Hard Cost / GFA (AED/m²)	6,173	6,135	6,171	6,154
Rating	LEED Platinum Pearl 4	LEED Platinum Pearl 4	None	None
Period	2009/2013	2012/2014	2008/2012	2008/2010

Table 3: Cost Comparison between two green buildings and two conventional ones

Interestingly, all four buildings cost less than their budgeted cost. Although one of the green buildings cost the most per m², it was only slightly higher than one of the conventional buildings. On the other hand, the Masdar HQ building cost the least per m² amongst all the buildings.

From this comparison, it is evident that green buildings are not necessarily more expensive than conventional ones at the core and shell level. Any cost premium therefore can be attributed to other factors such as the meeting of client requirements on the finishing level, or the technology, which was installed and used, regardless of whether the building was green or conventional.

5.1.2. Limitations

It is difficult to compare the “basic” vs. “green” cost, as the latter involves a different architectural design, not necessarily or solely the addition of green elements, each of them with a clear price tag that can be added to the basic design. Thus, research so far has calculated excess cost based on the average cost of green buildings.

Building a typology from a selection of buildings can hardly be as detailed as actual building specifications, which include hundreds of items. Moreover, every building has its own characteristics which affect the appropriate green solutions employed, as well as their costs and benefits.

Thus, research findings are inevitably limited to specific case studies, which make it difficult to extrapolate general features that apply to other green buildings. Still, they provide some indication in a market suffering from a lack of information concerning green constructions.

Another limitation in this case study is that the sample size is too small to allow for a representative sample that could provide statistically valid estimates of the average price of a green building compared with a conventional one.

5.2- Method Two: Case Study: Masdar Headquarters Building

This section will examine the sustainability criteria of the Masdar Headquarters Building and define the design and construction methodology used to deliver the project within the defined cost constraints.

5.2.1- Research Approach

The research questionnaire in this study was compiled using a combination of content analysis on a range of literature and existing research reports, which examined the cost premium of green buildings. These studies included the work of Snook et al., 1995; Sjostrom and Bakens, 1999; Poon et al., 2004; Tam et al., 2004 and the study of the article called ‘Do green buildings cost more’ published by the *Building Design and Construction Journal*; Nov 2003; ABI/Inform Global, (p. 9).

This interview questionnaire was also modified to capture other possible obstacles encountered from a management perspective, which would then provide a more comprehensive and deeper insight into the management culture adopted in delivering the Masdar Headquarters Building project. From this information, possible challenges and solutions can be identified from the experience gained working on the Masdar Headquarters Building during the course of the project.

Additionally, the survey results can be used to elicit expert opinions and feedback on its content from within the industry and field of study. Through this supplementary knowledge, along with the valuable opinions from managers and professionals involved in the Masdar HQ building project, quality findings can emerge and ongoing beneficial discussions can be held.

The interviewing questionnaire is as follows:

Planning questionnaire:

Q1- Are all projects fit to be green? If not, what would be the limitation for these projects, which could increase their overall cost?
Q2- How did the relationship between the master plan and the Masdar Headquarters influenced the cost?

Management questionnaire:

Q3- How did the clarity of the owner’s requirements affected the Masdar Headquarters cost?
Q4- How did the early defining of the green objectives affected the Masdar Headquarters cost?
Q5- How did selecting the right project team members affected the Masdar Headquarters cost?
Q6- How did the procurement method used affected the Masdar Headquarters cost?

Design questionnaire:

Q7- Did the design of Masdar Headquarters cost more than conventional ones? If so, why?
Q8- Did the use of a multi-rating system (LEED and Estidama) affect the Masdar Headquarters cost? If so, how?
Q9- How did the ongoing research of green materials and technologies affect the Masdar Headquarters cost?

Construction questionnaire:

Q10- Did the construction of Masdar Headquarters cost more than the construction of conventional ones? If so, why?
Q11- How did the maturity of the green product market affect the Masdar Headquarters cost?
Q12- Did the project management practices used in Masdar Headquarters differ from those used for conventional ones? If so, how did they affect the project cost?

5.2.2- Masdar Headquarters

5.2.2.1- General Overview

The new Masdar headquarters complex consists of three buildings within a 32,570m² of GFA. These buildings house the corporate offices of Masdar, the secretariat of the International Renewable Energy Agency (IRENA), along with additional office space for other commercial and retail companies.

The building has achieved Estidama Pearl Building Rating level 4 along with LEED Platinum.

5.2.2.2- Project Goals and Objectives

Economic

- Achieve Masdar commercial targets for the project development (cost per GFA of AED 7000m²)

Energy Efficiency and Greenhouse Gases:

- 50% reduction in energy demand from ASHRAE 90.1-2007
- 50% reduction in operational carbon
- 20% provision of renewable energy

Water Efficiency

- Achieve a 30%, reduction in water consumption compared to the defined benchmark amount of 180L PP/PA

Waste Reduction

- 50% diversion of operational waste from landfill, with a 90% construction waste diversion.

Certification Level

- Review paths of the least cost effective path to achieve both Estidama 4 Pearl and LEED Platinum.

Social

- Aspire to achieve a high level of occupant satisfaction. This includes, but is not exclusive to: air quality; internal, natural and artificial lighting environment; noise; external light pollution; visual amenity within the building, and to the outside; and the degree of control over the internal environment.

Materials Specification

- Optimum selection of local materials and local supply chains to achieve a 30% reduction in embodied carbon.

5.2.2.3- Management Strategies

The greatest challenge the project team faced was to try and find the right balance when attempting to meet the expectations of the various stakeholders, that at times were contrary to one another. For example, While the Masdar Headquarters' sponsors who financed the project were aiming to get a minimum of 12% Internal Rate of Return (IRR) for any financing they make on any project regardless whether it was conventional or green; In other hand, the Masadr City management had a mandate from the Abu Dhabi government to deliver the project at the highest sustainable standards as the project will host the International Renewable Energy Agency (IRENA). This difference in interests made delivering the project very challenging.

Therefore, it was important to raise the bar and to establish a clear vision to all the project team, from the beginning of the project, and to carry this story through every stage and individual decision of the design development, to the delivery.

It was also essential that the initial vision, objectives and priorities were established based on a deep consideration of the client values, along with the project and location context. This initial direction needed to be balanced and communicated clearly and the process employed needed to encourage integrated holistic design.

For that reason, it was very important to develop a decision making model between the four pillars of any sustainable development (Economic, Practicality, Social and Environment) whilst challenging the normal design assumptions, in the drive towards advanced performance standards. These categories were given weighting factors subject to their relative importance to the client. Each category is made up of sub-categories, which were again weighted according to their relative importance within that category.

As Estidama 4 Pearl ratings have different KPIs weighting than LEED Platinum, this can cause confusion on prioritizing which KPI gets the priority and at what cost. To ensure there was a common 'story' and clarity regarding design, development and direction, the KPI's and project delivery requirements were broken down by the design team into a short list of high-level headings that would allow a consistent and transparent cross-comparison of options throughout the project.

KEY CATEGORY	WEIGHTING FACTOR	SUB-CATEGORY	RELATIVE WEIGHTING
ECONOMY	30	OPERATIONAL COST	50
		CAPITAL COST	50
PRACTICALITY	30	FUNCTIONALITY	50
		BUILDABILITY	30
		SPACE ALLOWANCE	20
SOCIAL	10	AESTHETICS	50
		COMFORT	50
ENVIRONMENT	30	ENERGY AND CO2	40
		WASTE	10
		WATER	40

		SUSTAINABLE MATERIALS	10

Table 4: Decision making model

5.2.2.4- Design Strategies

The design development was directed by using the client brief requirements, and KPI's, including the prerequisite to achieve an Estidama 4 Pearl rating and LEED Platinum.

To enable design decisions and solution development to be informed by these multiple parameters, the design team used the decision-making model set by the project management team to assess each parameter's trade-offs. For example, If there was a surplus in the budget during the design shall they designing team go for a higher grade granite or shall they spend it on having a higher insulated windows which would reduce the cooling requirements. By looking at the above decision-making model, they would be able to make their judgment, which would have the highest weighting.

Passive Design Strategies Only

In order to achieve an efficient design, the following passive principles were applied where possible at no cost:

- The orientation of the building in order to minimize solar beam on the west and east orientations and reduce solar radiation on the south.
- The horizontal shading for the south orientated façade, as deemed more appropriate, and vertical for west and east.
- The maximization of the use of daylight on the north.
- The defining of the optimum building shape through the using of thermal modeling sessions in the early stage.
-The use of the latest software technology which allowed the design team to determine the optimum building width in order to maximize indirect daylight, thus reducing the use of artificial lighting.
-The introduction of courtyard spaces through the design in order to provide access to views out for the occupant.
- The development of outdoor thermal comfort through the external shading designed to provide an increased comfort level for pedestrians and to encourage individuals to walk and cycle around the site rather than depending on vehicle solutions.
-The use of a shadow range calculation carried out for the Masdar HQ site. The shadow range calculation provided an understanding of the most exposed areas and also shading distribution throughout the year.
-The use of passive cooling and natural ventilation: Prevailing breezes were studied and investigated to determine the way that the building form or envelope could capture and enhance these wind flows for natural ventilation of internal and external spaces.
- The utilization of traditional building techniques such as: evaporative cooling, semi-buried dispositions, a high-mass building envelope, high albedo materials, limited and strategic windows placement, etc.
- The use of air barriers in the envelope design to reduce air infiltration.

- The protection from wind and dust through minimizing the extent of horizontal surfaces upon which dust could settle. Where this was unavoidable, material surfaces were used, upon which, dust build-up would be less noticeable. Moving parts externally were minimized.

Active and Passive Design Strategies

Energy

The design team minimized the building energy demand through the selection of efficient fixtures and appliances (Energy star rating) and careful selection of HVAC systems that were appropriate to the region. A smart metering system was installed so consumers would be able to track their energy usage in terms of monetary values, in order to raise awareness and help to ensure ongoing energy conservation, once the project is completed.

Water

Efficient versions of fixtures and fittings were used in the project, which brought consumption down as low as 2.5 L/min. Water efficient taps are often the same price as less efficient models. The option, which was used, was the passive infrared sensors (PIR), which start and stop the flow when presence is detected in front of the tap. They can also improve hygiene as the tap does not need to be touched.

All toilets were equipped by dual Flush – these have two separate flush volumes, typically a 6 liter ‘main’ flush and 4 liter ‘reduced flush’.

All external irrigation systems were designed to be as efficient as possible, including controls to ensure they operate in the evening, and buried irrigation systems. Soils were selected to ensure maximum water retention rates to reduce the water demand of any planting. This was to be further developed as part of the landscape strategy.

Another cost effective strategy was the use of a solar hot water system to supply hot water to the office bathrooms and kitchens.

Materials and Finishes

The office building design aimed to specify durable materials that have: high recycle content, rapidly renewable content, low VOC’s, and low embodied carbon / low embodied energy where possible. They would be locally sourced and would have been Life Cycle Assessed (cradle-to-cradle). Materials were researched, environmental profiling was developed, performance parameters established and benchmarking against the MASDAR Restricted Materials List, was completed.

Low impact construction materials were investigated as a first preference in order to reduce embodied carbon. Materials with high-recycled content and reclaimed materials were also investigated and selected where appropriate.

Indoor Environmental Quality

Indoor conditions refer to those that are naturally comfortable and healthy for building occupants. A combination of materials with low volatile organic compound (VOC) emissions and sufficient air change rates to ensure decent air quality inside the building were utilized.

Technology Integration Criteria

The design team aimed to maximize the efficiencies of each adopted technology and to explore how they worked together in a fully integrated way to maintain the levels of efficiency. As with all complex systems, some can enhance one another when combined, and others may counteract their benefits. This fully integrated approach was tested during all stages of the design process. State of the art software was used continually to assess the viability of the technologies that were under consideration, and they were cost checked during the development process to ensure that both capital and life cycle cost effects could be measured.

Therefore it can clearly be seen that the design team followed the following steps in sequence, in order to minimize the project cost as much as possible while achieving the sustainability targets:

1. Adopt passive design strategies where possible.
2. Optimize the efficiency of all systems incorporated within the design - that is, use less to do more.
3. Use an appropriate level of technology to further enhance sustainable development.
4. Understand the sustainable design rating criteria to sensibly maximize results.

5.2.3- Sample Analysis and Data Collection

The questionnaire above was first sent via email to all the Masdar Headquarters Building project's stakeholders to prepare them for the face-to-face interview. The list of stakeholders included the client representative, the architect, the quantity surveyor and the contractor's project manager. All of the selected interviewees are LEED certified and they have all previously been involved in LEED certified projects. Therefore they all have a strong foundation and depth of knowledge concerning green building construction, and have the professional capability to advise on the designing of environmental friendly buildings. With their experience in planning, tender and procurement, construction, and commissioning of green buildings, it was evident that they would be able to provide comprehensive inputs on designing and delivering green buildings cost effectively.

5.2.4- Discussion

All the interviewees agreed to the fact that green buildings are not necessarily more expensive than conventional ones if they are executed well. They also supported the view that every building is unique in itself and that there is no one solution that fits all. For example, there are buildings that can achieve gold LEED rating at no cost premium while others add something between 5 % to 10 %, as a cost premium.

The reason for this, according to the design consultant is the fact that most clients look at sustainability objectives as 'add-ons', which can be added to any architecturally beautiful building. This can limit the optimization of most of the passive green design strategies and instead create a reliance on more active green solutions, which in turn can lead to an increase in the project cost. Another reason that was given for an escalation in green building costs was in the case of a very complex project such as a metrology lab which has substantial, restrictive requirements such as the acceptable vibration level, noise level, electric wave exposure, and so on, while trying to be sustainable at the same time.

In the Masdar Headquarters building, the client aimed to achieve specific sustainable objectives early in the project, which were included in the design brief sent out to the selected designing firm. This motivated the designing consultant to resource himself with the right LEED certified architects and project team to work on this project, especially as Masdar was adamant about not exceeding the budget of 7000 AED/sqm which made the task even more challenging, but also forced the team to become more innovative.

The design consultant also added that the relationship between the urban plan context and the building could also influence the overall cost of the project. For example, the plot size, shape, orientation and the master plan density can influence the building envelope, and the natural day lighting balance with the solar gain. This can lead to an increase in the level of technology which is used to supplement any site deficiency.
The client representative for the Masdar HQ building has also emphasized the positive impact that the master plan for Masdar city has had on the Masdar HQ building overall cost. He stated that, " Masdar HQ has got many points, from day one, by just being in Masdar. For example, Masdar gets higher points for using a water-based district cooling which was provided by the master developer. Another example was the ‘Electrical Vehicle’ designated parking with charging capability which was also provided by the master developer".

On the management level, according to all interviewees, failure to define the project green objectives at the early stage was the major cause of increasing the green project cost. As the design consultant pointed out, that most clients are focused on the architectural features of the building rather that the sustainability ones. This is understandable according to the architect, who highlighted the fact that the architecture of a building is more marketable than its sustainability, especially when the project is set on a prime plot (for example: with a sea view). The architect explained that in this case, the building owner or developer would try to maximize the exposure to the sea view by using more glass for the building regardless of its orientation. This can subsequently result in an increase in the heat gain of the building and therefore, on its air-conditioning requirements as well.

The client representative for Masdar HQ building also added that some owners tend to exceed the sustainability objectives in the wrong way. He said that, “most of the clients try to make sustainability more marketable by adopting more expensive technologies which can increase the project cost by much, for example, using smart sensors and untested technologies such as crystalized window tinting technologies." In the case of Masdar Headquarters building, he stated that the owner was very keen to achieve the greatest amount of sustainability targets with the minimum investment. He explained that this could only be achieved by emphasizing the innovative passive strategies the design consultant could apply which could only happen by selecting the right team members for this project and clearly outlining all the constraints at the beginning of the project.

The way the project is procured is another strategy, which can reduce the green project’s overall cost according to the contractor’s project manager. He stated that Masdar HQ was built below the present budget due to the better integration between the design and the execution. This was only successful due to the ‘design and built contract’ which allowed the contractor to be an integral part of the design team and provide his views on a design scheme, which would reduce the complexity of the building and the use of expensive technologies, especially by trying to maximize the passive solution in the design stage instead. At the Masdar Headquarters building, the design and build contract started on the schematic level rather than the concept level. He stated that most clients like to control the concept design stage and would allow them to get comparative prices from all bidders for the Design and Build stage.

In regards to the design fee for green projects, the design consultant stated that green building designs cost more than those for conventional buildings (around 10 % more than the conventional design fee) due to the extra activities needed for green buildings. These activities include site analysis, building modeling and the higher amount of research needed for green projects to define the most efficient materials and technologies to be used. The recording level and the documentation is more extensive and important for any green projects seeking to be certified. The certification process is another cost element for the designing consultant. In saying that, the consultant also highlighted the fact that more LEED architects are available nowadays and it is becoming trendy to be associated with LEED. Therefore, most consultant firms are not paying any extra for LEED certified architects compared to the past.

The design consultant also stated that using different rating systems can also increase the project's overall cost as different rating systems use different weighting for their sustainability KPIs. This variance in weighting among different rating systems is due to the importance of the different problems they are trying to solve. For example, in the table below, LEED places more emphasis on reducing the power demand than Pearl, whereas Pearl emphasizes much more significantly the reduction in water demand. As LEED was initiated in the US, it is understandable that power is a major concern in there compared to water, which they have in greater abundance. Conversely, in the UAE, where the Pearl rating system originated, water is a much more scarce resource than sources used for energy. Consequently, reducing water demands is a higher priority.

KPI	LEED Weighting	Estidama Pearl Weighting
Energy	24.5% reduction in energy demand	16% reduction in energy demand
Water	5.5% reduction in energy demand	25% reduction in energy demand

Using a multi rating system like that used for the Masdar HQ building can make the process more complex, and more difficult for the design team to balance and trade off between different KPIs. Ultimately though, the reason the owner requested LEED platinum Certificate and Pearl 4 for the Masdar Headquarters Building was purely a marketing one.

Another design concern which can increase the design cost, but in contrast, reduce the project cost at a greater value is the ongoing research regarding the latest green materials and green technologies. These are being developed and modified on a daily basis, and an increasing number of efficient green products are being released into the market, and at lower costs. The cost consultant also stressed the fact that a green building owner needs decide on how important the long term benefits are to him. He said that some developers, especially the speculative ones, are keen to keep their project cost at the bare minimum to increase their exit margin, while other developers are intending to retain the asset for a much longer period of time and are looking at the cost of the product life cycle rather than the project life cycle.

In the case of the Masdar Headquarters building, the owner will retain the ownership of the building which therefore has meant that a greater emphasis was placed on the operational cost, even if it in turn leads to an increase in the project cost. The quantity surveyor was mandated to produce a quarterly market research report on the newest green technologies and their relation to reducing the product life cycle cost, using financial tools such as Net Present Value (NPV).

When asked whether green buildings cost any additional premium over the conventional ones, answers given by the quantity surveyor differed to those supplied by the contractor. The quantity surveyor stated that LEED Gold buildings can cost an additional premium up to 10 % compared to similar conventional buildings. However, when the same question was asked of the contractor his answer was that LEED certified buildings, and in some occasions Silver and Gold LEED buildings will cost little more (not more than 2%) or nothing than conventional ones. However, this was dependent on the contractor being involved early in the development of the design. This difference in views can be due the familiarity both parties have in developing green buildings. When the quantity surveyor was asked on how to estimate the project cost in the design stage, he stated most of QS firms just add an additional 10 % cost for the green element. This explains the resistance to go green by many developers as most of them focus on the initial investments rather than the long term benefits. Such misleading feedback concerning automatically assigned higher green building costs can act as ongoing deterrents to any green initiatives that the client may aspire to have.

In the case of the Masdar Headquarters building, the contractor stated that they were able to reduce the initial projected project budget due to the fact that they were scoped to develop the concept design further in a design and build contract. This allowed him to input may beneficial suggestions on how to achieve the green objectives of the project, in a cost effective way. Another interesting comment that the contractor made that has not been mentioned in any of the literature that was reviewed, was the importance of the relationship that the contractors have with the vendors and suppliers of green products and technologies, and how it can affect the green building cost. The relationship that a contractor has built with such vendors and suppliers can qualify him to much greater discounts compared to the published costs of the products and technologies. This is because most contractors are major clients of these suppliers and vendors who maintain their competitiveness in order to retain them. Most QS firms and designing consultants on the other hand, do not have access to these discounted prices and so include the full published costs in their projected, project budgets.
This has also raised the question about the maturity of the supply chain market on the project overall. In the responses, there was general agreement that the more mature the market is, the more new technologies and green products will be available, and at very competitive prices. However, all the interviewees stated that the UAE market is lacking sufficient green products suppliers and vendors. This could change in the future as market awareness of green projects and their benefits, increase.

The contractor also addressed another factor which can reduce project costs; that is, by finding an experienced project manager in building green projects. He said that the management of green projects is more complex than managing of conventional ones, including the level of communication that is required. Consequently, such a project manager needs to have an additional set of skills over and above the average project manager, especially in the absence of any green project management frameworks compared to conventional project management frameworks such as PMI and PRINCE 2. He also stated that in the construction industry there is a very limited number of experienced green project managers compared to the design consultancy firms. Apparently, securing the services of a good project manager with experience in building green projects can be a bit challenging, according to the contractor, and can result in an increase in the soft costs of the project. However, he pointed out that as more green buildings are built, then the number of experienced green project managers in the market should increase.

5.2.5- Limitations

The sample size was limited to one case study. In the future, when more green projects are being built in the UAE and their data is available, then another study will be very beneficial to structure a best practice model, which can be applicable in delivering a cost effective green building.

Another limitation was that this study was limited to the UAE and further studies in the GCC countries would be needed especially as they share the same social requirement and expose to the same climate challenges.

One last limitation was that the method used in this dissertation was for commercial green buildings. Therefore, further studies will no doubt be needed to examine other green buildings types in the future.

6- Conclusions and Recommendations

6.1 Conclusions

The main aim of this study was to determine whether green buildings cost any additional premium over conventional buildings, and if so, how much that would be. There were many study reports and articles about green buildings in the literature review, which was carried out during the preparation of this dissertation, which talked about the long term benefits of green buildings and how their initial investments would pay off within a certain period of time, once the building was in operation. However, the amount of literature, which specifically addressed the claim that green buildings cost more than conventional ones, and identified this cost difference, was very limited.

The study reports and articles that did talk about the initial costs involved in green building design and construction, revealed some contradicting conclusions. Some of the literature supported the fact that green buildings do not necessarily cost any additional premium over that of conventional ones, if carried out correctly. In contrast, other authors of the literature reviewed, claimed that green buildings do, and would cost more than conventional ones. They also asserted that the premium rises with the level of certification from 5% to as much as 20%. Naturally, these conflicting results have continued to cause misunderstanding and uncertainty around the area of sustainable building design and construction, and also they have acted as a barrier to any serious attempts to transform the real estate industry into a green one. These concerns have not only been raised by private investors, who make up the majority of those with green building issues, but even by the government sector which makes this matter a serious one.

To assess these claims in the context of the UAE, two methods were adopted:

Method one involved the examination of the cost per square meter of two green buildings with two similar conventional ones which hadn't considered any green objectives specifically. This comparison included the construction costs (shell and core), the HVAC (excluding air conditioning as the green buildings are tapped to a centralized district cooling plant), the finishing of public spaces, and above or underground parking spaces. On the other hand, it excluded the design fee, the land price, and the cost of the finishing items. All the buildings, which were selected, had been built around the same period (2008 to 2014) to make the comparative study more valid. However, both the green buildings were procured as a 'design and build' after the concept design, while the other two conventional buildings were procured traditionally (design-bid-build).

Method two involved the interviewing of all key stockholders in the Masdar Headquarters Building (which is the case study being used for this dissertation). The aim of these interviews was to investigate the methodology that had been used to complete the green project (Masdar HQ building) successfully. The questionnaire that was prepared for the interviewees and the subsequent interview discussions attempted to identify any different cost elements in the design and construction of this green building, along with the practices that been adopted to ensure the cost effectiveness of the green building.

Using these methods enabled a deeper understanding to be gained on the initial cost of green building in the UAE. From the outcomes of the comparison in method one, it was clearly evident that green buildings do not necessarily cost any additional premium over conventional ones. In fact, one of the green buildings cost less than the conventional ones even though it was a LEED platinum. The results of this comparison is similar to some of the findings of the study reports and articles in the literature review and therefore claims about green buildings costing more seem to be both subjective and localized.

In order to analyze this issue in greater depth, the Masdar Headquarters building was chosen to be investigated further in order to understand the reasons which had enabled this green project to not only be delivered below budget, but also to achieve the lowest construction square meter rate among the four buildings in the comparative study, even though the project was LEED platinum and Pearl 4. Method two was employed to achieve this aim.

A number of key people representing the different groups involved in the design and construction of the Masdar HQ building were selected for the investigative interview. The list included the client representative, the architect, the quantity surveyor and the contractor's project manager. All of the interviewees are LEED certified and they have all previously been involved in LEED certified projects. Consequently, the interviewer knew that he was dealing with people who had a sound knowledge of the green building industry and the experience to go with it, plus the professional capability to scrutinize and advise on the cost elements involved in designing and building environmental friendly buildings.

The research questionnaire in this study was compiled after undertaking a content analysis on the relevant information in the literature review, which examined the cost premium of green buildings. This interview questionnaire was then modified so that it could identify, from a management perspective, some of the challenges and obstacles faced at this level in relation to cost. Additionally, it would help to gain a more comprehensive understanding of the management culture adopted in delivering the Masdar Headquarters Building, and how it related to the project's cost efficiencies.

Results from the interviews revealed that there are some key success factors which led to the successful completion of Masdar HQ building, and in the most cost effective way. The main key success factor, which helped reduce the project cost, was that the owner had decided explicitly ahead of time, to achieve clear green objectives. This was part of the design brief that was given out to consultants before they bid. These clear objectives made it possible for the design consultant to assemble the right design team for the project, especially as the maximum project cost was not allowed to exceed the AED 7000 per square meter mark, which was the mid market rate used for a similar grade conventional building. By having the green objectives set ahead of time along with the budget, the additional costs that usually result from adding on green features and technologies at a later stage were avoided according to the interviewees.

Another key success factor, according to the interviewees, which helped keep the project and its budget on track, was the connection with the master plan. Some master plans can lead to an increase in project costs irrespective of whether they are conventional or green. For example, as part of its design guideline, a master plan can dictate that underground parking must be provided. This would then to an increase the project cost, power demands and ventilation requirements. In contrast, another master plan could allow a developer to install an over-ground parking area which would mean that natural ventilation and light could be used, and the underground excavation and building costs eliminated. In relation to the importance and impact of the master plan on the project and budget, there is no real difference between green and conventional buildings. Both building types can increase or decrease in cost with changes to their master plans. For example, in the case of the Masdar HQ building the master developer provided all the buildings with a highly efficient water-based district cooling system which not only reduced the project cost, but also allowed them to get credits from the master plan for that too. The master plan can also state the plot shape and orientation which can help maximize the passive strategies for a green project.

Another important factor that can lead to a reduction in project costs is where there is a better integration between the design and the execution teams, as happened during the Masdar HQ building project. This higher level of cohesion between the two teams was possible due to the procurement type which was used. For example, the Masdar HQ project client hired a design consultant to design the project up to the concept design stage. The project was then procured again as a design and build contract where the contractor developed the design further. This allowed him to interact with the design team and share with them, his views and knowledge on how to achieve the given sustainable objectives, cost effectively. This procurement method incentivized both the consultant and the contractor to deliver the project at the minimum cost while achieving the clients' green objectives.

Allowing enough time to do research into the latest high performing green technologies and products can also help to reduce these costs as the market keeps evolving with newer and higher performing technologies coming on stream at very competitive prices. As for the UAE market, the availability and range of green products and technologies are not nearly as prolific as can be found in Europe or the US. Consequently, the prices of these green items remain relatively high, especially as the number of suppliers and vendors in the UAE are also very limited. Despite this situation, cost savings can be achieved by using large and reputable contracting companies that are able to buy these products at discounted prices through their relationship with vendors and suppliers.

Although the interviewees were able to identify a number of key factors that lead to the cost effective construction of the Masdar HQ building, they also pointed out several areas where costs can escalate rather than decrease. One example is that most consultants and contractors incur more soft costs on green projects than conventional ones (around 10 % more than the conventional design fee) due to the extra activities needed for green buildings. An example of this the extra work required in the site analysis and building modeling. Also, green projects usually require a greater amount of time spent in research in order to determine the most efficient materials and technologies to be used. Additionally, more time and skill is required to meet the higher level of record keeping and documentation for any green projects seeking to be certified. This certification process is another cost element for the designing consultant. On the positive side, the design consultant who was interviewed highlighted the fact that there are now more LEED architects who are available in the market place, especially as it is now coming to be seen as advantageous to be associated with LEED. Consequently, many consultant firms are now not paying any extra for LEED certified architects compared to in the past.

Unfortunately, this is not the case for contractors in the UAE. Finding an experienced project manager in green buildings is very difficult and subsequently, most contractors end up having to pay extra to secure their services. Any additional cost involved in employing such a project manager is considered worth it as it is a crucial role in the project. The project manager has to manage all aspects of the construction process, including the budget, which is very challenging given that green projects are more complex to manage than the conventional ones. To complicate matters further, there is a lack of green project management frameworks compared to conventional project management framework such as PMI and PRINCE 2 which can be used.

Another additional cost factor that was noted by the interviewees in relation to the Masdar HQ building was in the area of sustainability certification. While it was commendable that the Masdar HQ project aimed for more than one green certification, it did mean that the difference in the weighting between those systems increased not only the soft costs but also the hard costs. This was partially due to the difficulties that the design team faced when trying to trade off between the various green objectives, depending on their weighting, which meant that in most situations they ended up relying on more active and costly solutions.

In conclusion, the key significant finding of this study showed that green buildings in the UAE do not have to cost any more premium than conventional ones, if they are probably designed and managed from the start. Many of the claims made about the higher cost premiums of green buildings appear to be driven mainly by one or more of the following reasons as per the literature review and interview feedback:

- Many private real estate developers in the marketplace are perpetuating the myth that green buildings cost more than conventional ones without any validation; it is often based on what they have heard or on very old studies where the technologies were more expensive.

- Most of clients look at sustainability objectives as add-ons which can be added at a later stage to any design, which limits the optimization of economical passive green design strategies, and instead promotes a greater reliance on more active green solutions which can lead to an increase in the project cost.

- Some building project involve much more complex designs and structures as in the case of a metrology lab which has very restrictive requirements in relation to certain elements such as vibration level, noise level, and electric wave exposure, and so on while trying to be sustainable as well.

- Some master plans can escalate project costs due to various aspects such as the size or shape of the plot, or its orientation not being optimum for green buildings.

- Most clients are initially and primarily focused on the architectural features of the building rather that the sustainability ones. This usually means that the green objectives of a project are not clearly defined at the early stage which is a major cause of increased green project costs.

- Many projects use traditional procurement strategies that are not the best fit for green building projects. For example, the 'design-bid-build' approach does not provide the opportunity for inputs from the execution team during the design stage, which can increase the project cost and lead to some design changes.

- Most green project designs cost more than conventional ones, in general, due to the extra activities needed for green buildings. These activities include: site analysis, building modeling, greater amounts of research into defining the most efficient green materials and technologies to use, increased recording and documentation levels for sustainability certification, and the certification process itself.

- Multi rating systems can increase green project costs. By using more than one rating system, as in the case of the Masdar HQ building project, both the soft and the hard costs can increase. It can also make it more complex for the design team to balance the trade off between different KPIs and lead to a reliance on more active strategies·

- Many green project teams lack the necessary information regarding green products and technologies due to a lack of research and, or, availability of such information. Consequently they do not always have access to these items at more competitive prices or greater cost efficiencies. Additionally, there is also a lack of green product suppliers and vendors which can keep the cost of such products much higher than in other parts of the world where there is greater supplier competition.

- Many architects and building consultants are still not familiar with how to design green buildings, or they are too comfortable with the way they are doing things at present.

- Many contractors are adding an inflated risk premium to their project estimates due to their lack of experience in constructing green projects.

-Many of the current green buildings are designed to be a showcase and rely heavily on using cutting edge technologies in those buildings, or they have been designed as iconic constructions, which have increased their project cost.

Although the lack of knowledge and competency in green building design and constructions can contribute to the increase costs of green buildings, the study did reflect an increase in awareness amongst consultants and contractors concerning the cost of green projects, and more of them are coming to see that green buildings do not necessarily require any risk premium, especially in the UAE.

The literature review, however, did reveal some contradictory results where one study concluded that green buildings might cost an additional premium up front, but in the long run they would save so much on operational expenses, that it would significantly outweigh the additional, initial investment cost. In contrast, other research results supported the premise that green buildings do not need to add any additional cost to a building project, if they are designed and constructed well, such as through the kind of strategies outlined below in the recommendations of this thesis study.

Finally, the results of the case studies used in this thesis study, confirmed that there was very little difference between the final cost of the two green buildings, up to the core and shell stage, with that of the two conventional buildings that were built in the UAE, at the same time. In fact, both the green buildings, the Siemens Headquarters, and the Masdar Headquarters, were built under the estimated budget, as were the conventional buildings. The Masdar Headquarters building actually cost the least amount of all four buildings despite some of the stringent sustainability requirements it had to meet as being part of the Masdar City Development.

6.2- Recommendations

Recommendations regarding the development of green buildings in the UAE, or elsewhere, which were derived from this study, can be summarized as follows:

- Define the green objectives early in the project and explicitly mention them in any design tender document with a well defined maximum budget.

- Understand that the interrelationship between the project and the master plan can help or hinder achieving the project targets in a cost effective manner.

- Ensure that there is a well managed and careful integration between all those involved in the project team, especially during the design stage, is absolutely vital if the overall project cost is to be controlled.

- Use a design and build procurement strategy to improve the communication between the exception? team and the design one which will provide a cost effective solution for achieving green objectives.

- Adopt passive design strategies, where possible, in order to keep costs down.

- Use one rating system if possible, and make sure that, that system addresses the major concerns.

- Allow enough research time to find the most cost effective and efficient green products. And use an appropriate level of technology within a realistic pricing structure to help make even greater gains in sustainable outcomes.

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