QATAR UNIVERSITY

COLLEGE OF ENGINEERING

SUSTAINABILITY PRACTICES IN FACILITY MANAGEMENT

BY

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A Thesis Submitted to the Faculty of

College of Engineering

in Partial Fulfillment

of the Requirements

for the Degree of

Master of Science in Engineering management

January 2017

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Abstract

Facilities management (FM) has witnessed a pragmatic growth and its importance has increased parallel to the expansion of the construction sector. Meanwhile, the concept of sustainability is being established and is considered an essential topic nowadays. Sustainability standards and accreditations are adapted now to design and erect buildings; however, this will not ensure building efficiency during the building's life cycle.

Integration between facility management and sustainability practices should take place in order to raise a building's performance and achieve energy conservation throughout the building's operation.

Although much research has been conducted in sustainability, very little researches have investigated the topic of sustainability in facility management.

The rational of this study is to get a more thorough understanding of facility management practices and sustainability strategies adopted by different FM departments in Qatar. This research could be considered as the basis for FM research because no such previous research is available for Qatar. Moreover, this study aims to investigate and analyze energy consumption, FM practices, and users' satisfaction through several case studies in FM educational campuses in Qatar.

The first objective of this study is to conduct a comprehensive review of existing FM sustainability plans, strategies and practices on various educational campuses in Qatar by numerous cascading levels of stakeholders; starting from FM managers, engineers, technicians and finishing with users. The second objective is to investigate the knowledge

of FM teams regarding sustainability concerns and practices. The third objective is to analyze energy consumption data for different buildings across multiple campuses in Qatar and benchmark them with ones abroad to evaluate energy performance for Qatari campuses. The last objective is to propose sustainable practices that could be implemented to reduce energy consumption during building operation.

The methodology that is adapted to collect data for this study consists of qualitative and quantitative methods. The interviews represent the qualitative methods and the survey- questionnaire represents the quantitative method. Moreover the energy consumption data analysis is classified under the quantitative part.

The energy consumption was collected for different ten buildings as case studies inside Qatar educational campuses and was analyzed to benchmark them with other broad campuses. Moreover the electricity consumption was benchmarked with Energy star standards for educational campuses in order to give a full image about electricity consumption pattern.

Interviews were conducted with 20 participants and 105 participants had filled the survey – questionnaire. The results that were concluded from the interviews and surveys were convergent showing that FM teams lack sustainability training. Sustainability practices are not well understood and implemented by FM departments except planned preventive maintenance that is implemented with a high consideration in campuses and it supports energy conservation. Users' satisfaction regarding services was good, but was not adequate regarding indoor air temperatures as a lot of users are feeling cold and uncomfortable. An energy consumption analysis was done too and it revealed a continuous increase in energy consumption as the number of occupants is increasing and this is pointing out the need to consider sustainability practices.

The main results showed that although the EUI value for the case studies is meeting the energy star standards for most of the buildings, compared to broad campuses Qatar campuses are consuming much more electricity so the results of EUI is not accurately representing energy performance. This was more apparent since benchmarking of buildings abroad was studied in terms of consumption per occupant. To get more accurate results on energy performance patterns, the consumption per occupant was calculated for all of the studied buildings and benchmarked with campus buildings in other countries. The results showed that the consumption per occupant in Qatar is 1.5-2 times more than broad campuses. The results of the study found that energy consumption for classroom buildings and office buildings is the same, although building types and functions are different. The type of HVAC system is highly effecting energy consumption , it was found that HVAC with DX system is consuming 4-5 more times that the district cooling system which needs to be taken into consideration in future projects and studies could be conducted to investigate the feasibility of changing the current DX in to other energy saving systems.

Table of Contents

List of Tables

List of Figures

Abbreviation List

AA	Aspire Academy
ACMV	Air conditioning –Mechanical ventilation
ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers
BEI	Building Energy Index
BIM	Building Information modeling
BMS	Building management system
Btu	British thermal unit
CBECS	Commercial buildings energy consumption survey
CCTV	Closed-circuit television
CFCs	Chlorofluorocarbons
Co/Oc	Consumption per occupant
CIA	Central intelligence agency
EIA	Energy Information Administration
EMS	Energy management system
EPA	Environmental Protection Agency
EUI	Energy Use Intensity
FM	Facility management
GCC	Gulf Cooperation Council
GHG	Green house gas
GSAS	Global Sustainability Assessment System
HVAC	Heating ventilation air conditioning
kWh	kilowatt hour
LEED	Leadership in Energy and Environmental Design
MEP	Mechanical- electric- plumbing

QF	Qatar Foundation
QU	Qatar University
SBEMS	Simplified Building Energy Modeling system
SUS	Sustainable/sustainability
SUS FM	Sustainability in Facility management
UOO	University of Oregon
USGBC	United States Green Building Council
WCED	World Commission on Environment and Development
WO	Wisconsin Oshkosh University

Acknowledgements

At the beginning and at the end, at all times I thank God for this and every opportunity, every advantage and disadvantage that I came across during this research towards becoming a more improved professional.

I am grateful to a lot of people that offered me support in this research in a variety of ways. First of all, my academic thesis advisor, Dr. Djamel Ouahrani for his continuous and timely assists. He offered advice and guidance throughout this research process.

This research would not have been successful without the assessment of the facility management departments in the studied campuses, they were all delightfully cooperative. My special thanks to the Engineer Hitham Ashour at the Qatar university campus for his extensive support and help in the data collection process and interview. I would also like to include engineers Mohamad Kutty and Basma Mesbah from facility management at Qatar university campus.

The Aspire logistics team were additionally extremely helpful, my special thanks goes out to Engineer Alaa Elsamak for his assistance, informative feedback and time.

Qatar foundation facility management offered me informative support and data therefore I would like to take the opportunity to thank Mr. Shashidhar Hegde.

I'm also grateful to all the experts and respondents that gave up their time for interviews and surveys.

Significant milestones in life are only achieved through the help of friends and family members, it is essential for them to uphold their encouragement to keep us going.

I'm indebted to my parents, husband and brothers for their endless prayers, care and attention during this research.

I found this research to be exhausting from time to time, perhaps frustrating too, but rarely - but almost I found it satisfying. However this endeavor has been fruitful overall and this is because of the help that I received from those around me.

Dedication

To my parents … their extensive encouragement and prayers

To my husband … his support and patience

To my kids… their time taken for this research

To my brothers…. their encouragement

Chapter 1: Introduction

Sustainability and sustainable buildings

The Brundtland Commission (1987)[1] reported, "Sustainable development aims to meet human needs while preserving the natural environment so that these needs can be met not only in the present but also indefinitely in the future." Sustainable development has offered the world a novel perspective on protecting environmental systems to serve both present and future generations and it could be briefly defined as environmental, economic, and social wellbeing for today and tomorrow.

The given definition shows the basis for the sustainability model in diverse approaches and implicitly insists on the rights of future generations to have adequate amounts of raw materials and energy. Buildings are responsible for about 40 percent of total national energy consumption during their operation; they are also responsible for the same percentage of greenhouse gas emissions and for about 70 percent of electricity use (Wood, 2005). To address energy efficiency and environmental concerns during their running stage, buildings must reduce their energy use, including water and electricity to save resources, protect the environment and enhance inhabitants' quality of life. One of the greatest opportunities to address this need is to speed up the development of sustainability practices in buildings, facilities management, building information modeling (BIM) and energy management systems (S-BEMS).These aim to improve the environment within a building is to ensure the comfort of the inhabitants.

1 The World Commission on Environment and Development (WCED), popularly known as the Brundtland Commission, was tasked with formulating a global agenda for change (UNCSD, 2010).

As a result of this, sustainability in buildings is considered to be one of the most concerning aspects of sustainability itself. Lucaset al. (2013) have argued that sustainability in buildings requires multidisciplinary actions in all important areas. Moreover, it requires the involvement of all stakeholders in the decision-making process, starting from owners, designers/contractors to the users. Sustainability in buildings implies capturing a holistic, comprehensive image of events, plans and actions as far as they can be captured. This kind of union assumes that all aspects of a system have to be measured and audited. This measurement of sustainability has to continue through buildings' life cycle, this is why facilities management (FM) plays an important role in achieving this.

Positioning the problem: Energy use in Qatar and the complexity of the FM field

Tucker et al (2012) has concluded from his study that the development process of sustainability in FM is complex because it involves various disciplines. This difficulty creates disorders and gaps in properties and facilities in need of development. Despite a generally wide understanding of the development process, FM is not yet recognized aside from two common FM aspects which are maintenance and operation. This recognition prevents the use of FM as early as possible in the planning stage of the building. Moreover, an FM team might lack clear knowledge of professional sustainability practices that would highly impact building performance. This is due to the fact that all sustainability goals mentioned above are hard to achieve.

Purpose study and significance

Problem statement

Given that sustainability has become a buzzword in the international arena, numerous approaches and theoretical frameworks have been proposed to support implementing this concept. This study is intended to investigate potential means of incorporating sustainability and facilities management themes into formal practices by understanding and benchmarking the most common successful implementations of this integration and by analyzing energy use and energy consumption patterns in several case studies.

This research aims to answer the following questions:

1. What is the current situation of sustainability for FM in Qatar?
2. What are the FM practices that could be implemented to support sustainability?
3. Can energy use intensity (EUI) measurements represent energy performance accurately?

Research objectives and scope

The objective of this study is to investigate sustainability in facilities management in Qatar along with current practices and sustainability strategies adopted by different FM departments in Qatar. This research could be considered a cornerstone of future FM research, as no such previous research has focused on Qatar. Moreover, this study aims to examine and analyze energy consumption, FM practices and user satisfaction through several case studies on different campuses, especially education campuses in Qatar.

The detailed objectives of this research are listed below:

- Conduct a comprehensive review of existing FM sustainability plans, strategies and practices on various campuses in Qatar conducted by numerous cascading levels of stakeholders; starting from FM managers, engineers, technicians and reaching users. This review takes two research methodology approaches, these being qualitative interviews and quantitative survey questionnaires.

- Investigate the knowledge of FM teams regarding sustainability concerns and practices.

- Analyze energy consumption data for different buildings across multiple campuses.

- Benchmark buildings in Qatar with ones abroad to evaluate energy performance for Qatari campuses.

- Propose sustainable practices that could be implemented to reduce energy consumption during building operation. Those practices will be referred to collectively as a campus sustainability plan.

Thesis outline

Thesis structure is summarized as follows:

Chapter 2 contains a detailed review of the literature to recognize frameworks and approaches used by other researchers in order to provide a basis for investigation and benchmarking. This is concluding facilitates benchmark buildings' energy performance during their operation. Moreover, it offers sustainable practices that were investigated by researchers in buildings, which could be implemented to reduce the energy consumption during buildings operation.

Chapter 3 describes the planned methodology to be conducted in order to meet the study's objectives. The methodologies include conducting a comprehensive review of existing FM sustainability plans, strategies and practices across various campuses in Qatar through looking at various cascading levels of stakeholders. This review takes two research methodology approaches: qualitative interviews and quantitative survey questionnaires. The chapter also includes an explanation of the data that must be collected for analysis of energy consumption.

Chapter 4 presents the data collection procedure and some of the collected data, moreover it represents how the gathered information will support the analysis and results chapter.

Chapter 5 presents the analysis of the survey questionnaire and the energy consumption data to determine the final results and findings, which act as the input for the proposed campus sustainability practices and plans.

Chapter 6 contains the conclusion and recommendation.

Statement of originality

The present research comprises of an innovative investigation of the use of EUI to accurately represent energy use and performance in buildings.

Chapter 2: Literature Review

Introduction

This research focuses on sustainability in facilities management. From this point of view, the field has undergone a shift and researchers are now focusing on the reasons buildings operate unsustainably and practices that could be adopted during building operation to improve existing buildings' serviceability and to meet several sustainability objectives, such as to improve indoor quality and reduce energy consumption. This literature review acknowledges prior writing in relevant fields, although research in sustainability in facilities management is still in its infancy and is thus limited.

The benefits that new technology could add to facility management on the field of sustainability is massive ; specially when applying controlling systems , moreover BIM applications are intended to serve sustainability in FM . Those topics are going to be discussed in brief in this research as they are not in the scope of work for this study.

Since no previous research was conducted about sustainability in FM in Qatar the researcher had started from scratch and the scope of work needs to be limited according to time and resource limitations but those topics are very important to be studied in future work.

The first section of this chapter focuses on the theoretical and academic definitions of "sustainability" and "sustainable buildings." The second investigates reasons for operating buildings unsustainably. The third section collects best practices and approaches to improve sustainability in facilities management, covering various aspects such as energy efficiency and water consumption along with its social aspects.

The fourth section emphasizes the evaluation sustainability on education campuses and their sustainability plans too.

Sustainability and sustainable buildings

Becker (2004) has gathered that sustainability is based on achieving a balance among three dimensions (environmental, economic and social) over time, those are related to each other. In the building sector having a strong economy can establish a high quality building that will enhance people's social life and reduce environmental impacts. If planners concentrate on one dimension over another, they reduce the other two dimensions and negatively affect a building's development and growth. The critical focus of sustainability is to afford long-term building performance and good quality of life for inhabitants.

Geniaux et al. (2009) have mentioned that industry is increasing and populations are too. This is applying more pressure in the construction sector as more buildings are needed. Furthermore, not enough consideration has been given to the environment that must be maintained and a deterioration of resources will take place as a result. Having sustainable buildings will reduce energy consumption and GHG emissions, as a result it will preserve the environment.

Al-Gahtani et al. (2016) have illustrated that several ethical paradoxes are presented by sustainable development and sustainable buildings, as well as this both point toward multiple characteristics that could preserve buildings and mitigate future risks. As a result, the concept of sustainability must be considered sensitively and not used as a commercial logo for marketing. There should be faith for such a great idea.

When talking about sustainability, the building sector is a priority, since buildings affect and are affected by the surrounding environment. Additionally, buildings are a minor environmental factor of human living, and buildings are the spaces in which people spend 90 percent of their time, according to the Organization for Economic Cooperation and Development (2003). As such, offering a healthy environment and quality working conditions is crucial, as these enhance employees' productivity levels and accordingly to promote employers and their businesses.

Brauers (2004) has mentioned that nowadays all stakeholders, including owners and developers, are much more interested in sustainable buildings than they have been in previous years. This could be a great opportunity, as such buildings serve multiple stakeholders and sustainable buildings include "construction practices that incorporate sustainable materials, jobsite recycling, energy efficiency, renewable energy, careful site selection, utilization and indoor environmental health" (Tait, 2004). This means a lot of considerations should be taken by sustainable building planners, such as the use of friendly materials and minimizing energy consumption.

Catherine and Sheila (2012) have stated that focusing on energy consumption is a need; the data implies that buildings consume about 40 percent of total energy, third only to industry and transportation. Most of this consumption is related to conditioning costs, meaning heating and cooling. In the current decade, energy demands of the tertiary and residential sectors have annually increased by 1.2 ,1.0 percent respectively and this gives a significant indication of the rapid growth of energy demand in building sector. In this respect, sustainability in buildings is worthy of adoption and conversion of it into realistic daily practices is needed.

Sustainable development in GCC and Qatar

Version (2010) and Deloitte. GCC powers of construction (2010) had reported that GCC countries are on top in construction projects in terms of their investment as illustrated in figure1. This increase in construction causes enlargement in energy demand.

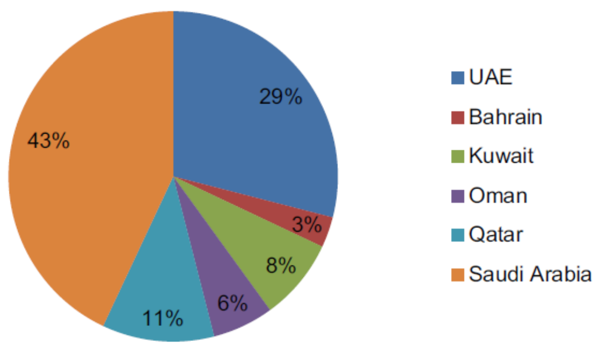

Figure 1: Construction projects in GCC by investment .Source: Deloitte. GCC powers of construction 2010

Central intelligence agency (2014) published that GCC countries are on the top of water consumption, moreover the GCC is ranked at the top for water desalination and this requires more energy. Table 1 shows the top five countries in terms of water desalination.

Table 1.Top five countries in terms of water desalination. Source: CIA(2014)

Country	Total production (m^3/day)	% of global production
Kingdom of Saudi Arabia	5,253,200	25.9
United States	3,092,500	15.2
United Arab Emirates	2,164,500	10.7
Kuwait	1,538,400	7.6
Japan	745,300	3.6

Energy use in Qatar

Energy information administration (2014) had reported that Qatar is one of the fastest growing economies in the world. Aside from this, energy demand in Qatar has increased notably, mainly regarding electricity. It has been reported by the US Energy Information Administration that Qatar had an extra generating capacity of about 2.5 giga watts, that is, around 30 percent, in 2012. Although there has been some development on solar power projects in the preceding years, there is still no significant production from solar power.

From 2000 to 2010, electricity expenditures in Qatar grew from approximately 8.0 billion kWh to 20.5 billion kWh. This expansion has continued and the Ministry of Energy and Industry of Qatar has declared that consumption from 2012 will be multiplied by 13 percent. One plan, announced in March 2013 proposes to spend $22 billion on electricity and water projects. This boom in electricity use has created pressure for the service and energy sectors, therefore there is a serious need to consider energy conservation plans in the building sector, refer to figure 2.

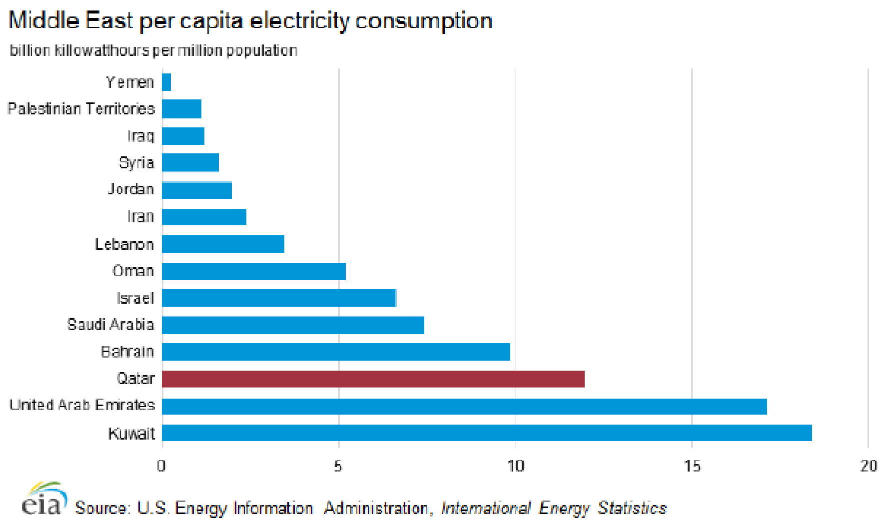

Figure 2.Middle east per capita electricity consumption. Source: Energy Information Administration(2014)

According to the Energy Information Administration, the per capita energy consumption in Qatar is nearly 11times greater than the world average as also indicated in figure 2 for the year 2014. Comparing gulf countries with the Middle East shows that gulf countries are consuming more electricity see figure 2, in which Qatar ranked third in the highest consumption after Kuwait and United Arab Emirates. Figure 3 shows the consumption for the year 2015 in which Qatar had the highest consumption compared to other Gulf countries, which reflects an increase in energy consumption for Qatar for the year 2015 compared to 2014.

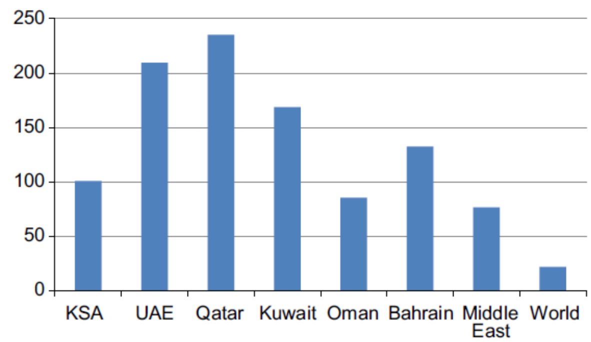

Figure 3.Annual per capita electricity consumption in MWh for the year 2015. Source: Energy Information Administration

Richer (2014) illustrated that Qatar's current carbon dioxide emissions are among the highest in the world. The level of electricity and water consumption by Qatar and countries within the Gulf Cooperation Council has exceeded that of chief industrial countries - Qatar now consumes much of the energy. As a result, this matter requires investigation and action must be taken to reduce environmental impacts and resource consumption.

Qatar National Vision 2030

Qatar National Vision 2030, a document published by the General Secretariat for Development Planning states the following (p.4): "For these reasons Qatar must develop at a pace that is consistent with the realistic expectations of sustainable improvements in livelihoods and in the quality of life. It must target growth rates that are compatible with its capacity for real economy expansion." It then emphasizes the importance of "the long term maintenance of strategic reserves of oil and gas to meet the needs of national security and sustainable development" (p. 16).

The importance of sustainability throughout building life cycle

Buys (2011), Gabe (2008) and Madritsch & Ebinger (2011) illustrated that to protect the environment, conserve resources and enhance quality of life for inhabitants, consumption must be reduced. One of the greatest ways to address this need is through the development of sustainability practices in buildings, facilities management, BIM, and S-BEMS.

Robertson and Jones (2004) have mentioned that running costs are highest during building phases, as the operational phase is the longest during life cycle of a building. FM teams are responsible for this phase and for addressing operation and maintenance issues.

Many researchers, including but not limited to Wood (2005), Lee and Kang (2013) and Robertson and Jones (2004) have stated that operations and maintenance costs range between 15 and 20 percent of an organization's turnover, and this varies depending on the efficiency of FM teams and on construction/design performance. As a result, any cut in design and construction costs could cause a harmful impact on an organization's working life, serviceability and profit. There is a relationship between changes and costs during different phases of any project. From design to operation, the influence of changes in a project decreases, whereas cost increases from design to construction reaching its maximum in the operation stage. As a result of this, operations should be taken into consideration as early as possible from the initiation and planning phases.

Wood (2005) has emphasized the need to address existing building stock to achieve sustainability goals and he has highlighted that the operational phase of buildings is actually key to the role of FM given that in the developed world, the majority of existing buildings are likely to remain for the coming 50 years, maintaining and transferring their embodied energy and operational energy requirements into the future. In addition to this, buildings equipped with inefficient heating, ventilation and air conditioning units emit 1.5 times the amount of carbon dioxide as those with energy-efficient units.

Sustainable facilities management

So and Mihyun (2012) have stated that facilities management includes work to ensure the functionality of built environments by integrating three Ps (people, place, process) with technology to sustain desired conditions, uses, products, values, and services from long-term and ecological views. Facilities management involves handling multiple operational and maintenance tasks; those tasks are categorized into different departments with different duties as reported by the British Institute of Facilities Management Professional Standards framework.

1. Hard services include:
    - Mechanical services
    - Electrical services
    - Plumbing services

- Civil and carpentry services
- Building management systems (BMS)
- Closed-circuit television (CCTV).

2. Soft services include :
   - Cleaning,
   - Security
   - Food services.

Shah (2007) has proposed that the concept of sustainable facilities management was developed parallel to the concept of sustainable development; it was also established according to the growing positive reception of the predicted climate change scale. Satterthwaite (1997) has stated that, “Sustainability in facilities management should provide a healthy living and working environment for residents and furnish them with clean air, clean water and provide the essential infrastructure for economic growth. Besides, it should keep an ecologically-balanced relationship with local and global ecosystems.”

Cigolini (2009), Azizi, Wilkinso and Fassman (2014), as well as Elmualim et al (2009) mentioned that sustainable FM aims to run buildings with the best efficiency in terms of providing and conserving both energy and resources. As a result, it is considered to be an operational practice that creates the longest possible lifespan for a building. This can be implemented by using systems such as efficient lighting to reduce energy use and greenhouse gas emissions, which may in turn result in lower operation and maintenance costs for a facility. Moreover, a scheduled maintenance plan serves a key role in maintaining facility systems such as HVAC, plumbing and electrical. Conservation of building systems and equipment assists in delivering a better indoor environment and more user satisfaction as a result. Furthermore, conservation mitigates the risk of sudden system failures.

Brauers (2004) has illustrated that the building controlling systems are useful for buildings to ensure environmental sustainability, address rising energy costs and reduce energy consumption in new and existing buildings. However, the integration of sustainability in facilities management is still a very new topic and not many relevant research studies have been conducted towards it.

Reasons for unsustainable building operations

Listing reasons why buildings run unsustainably is not that easy for the reason that many related issues are integrated within the early stages of a project. Moreover there are multiple disciplines related to a project or building. However, the most important reasons can be categorized under the following main groups:

- FM lacks an early involvement during project planning stages. Moreover, teams lack knowledge of sustainable facilities management (SUS FM), as Meng (2012) has illustrated.

- Lack of culture, coordination and knowledge of SUS FM has been argued by Elmualim et al. (2009), who have stated that the greatest barrier to implementing sustainability in facilities management is a lack of consensual understanding and concentration of individuals and organizations about sustainability. Additionally, there is a knowledge gap regarding real practices and practical information on how to deliver sustainable FM. Madritsch and Ebinger (2011) have similarly stated that despite the wealth of available research, FM knowledge remains fragmented across a large number of institutions and research groups. FM lacks a comprehensive and generally accepted framework that could be used to organize and classify the available knowledge.

- Regarding green assessment tools and accreditations, Azizi, Wilkinson and Fassman (2014) have argued that constructing sustainable buildings doesn't ensure energy-efficient performance. Moreover, the improper operation of sustainable buildings often results in higher energy consumption than in conventional buildings.

- Most sustainable assessment tools are concentrated in the design and construction stages as design and construction are easier to track in terms of sustainability aspects, referring to the short duration of design and construction compared to the duration of running the building itself. Recently, many assessment tools have been developed for rating building operations, but they are still not that common or understood by FM teams. It can be said in brief that assessment tools lack a clear framework for SUS FM (Gabe, 2008).

- The "Sustainability in Facilities Management Report"(British Institute of Facilities Management, 2013) states the following: "Barriers to the management of sustainability within organizations have seen that Senior Commitment has risen sharply since 2009 with organizational engagement having risen by a third since 2007. Both these areas support the continuing challenges of making improvements in sustainability performance in the current economic climate."

- Even though sustainable design procedures and practice cases have been provided, few case studies have stated how planners and facility managers identify the relative virtues of sustainability. Having investigated this problem, Sparks and Peattie (1998) mention that a handy checklist approach does not help facilities managers address conflicts and difficulties that they face during trials to implement sustainable strategies.

Facilities management in early project stages

Meng (2013) has illustrated that facilities management has witnessed a rapid growth since its inception in the 1980s. Following to its development, early FM involvement has attracted attention from industry professionals and researchers in the past decade, which makes it feasible to incorporate facilities management knowledge with experience into the design process generally.

There are two ways of integrating FM with construction. The first way is by using a delivery method of design and construction that serves FM involvement. The second is to incorporate early contractor involvement in the design stage. Adopting these methods in terms of constructability in design–build practices will reduce problems, as the interface between contractor and designer and early contractor involvement takes into concern familiarity with construction, knowledge, and experience. All of the listed aspects are taken into account as feedback in the design process so that constructability can be improved together with project performance (Thomas, 2006).

Since FM is still typically recognized to be a post-construction service, direct involvement of FM specialists in design has regularly been absent or minimal at best (Edum-Fotwe et al., 2003).

Duffy (2000) has suggested that design and construction teams should welcome contributions by facilities management teams and on the other hand, facilities management teams should be learned who to work with aside from architects and designers. The early involvement of FM in both design and construction phases must aim to solve expected problems. Meng (2013) has listed several advantages of early FM involvement which could be classified as benefitting the main stakeholders in the process. The diagram in Figure 8 summarizes those benefits.

Elmualim et al. (2009) have listed what makes FM involvement difficult. These reasons can be classified according to the following categories:

- Fragmentation and complexity of the industry, which leads to extensive use of subcontractors
- Poor communication and lack of trust

Tucker et al. (2012) have highlighted the advantages of integrating FM in the strategic planning of a project followed by other main stages which are initiation, evaluation, project planning, design, costing, and construction. Furthermore, they consider that there is a significant connection between facilities management, project management, and property development beginning from the design/construction phase. Creating this new framework would benefit sustainable development significantly.

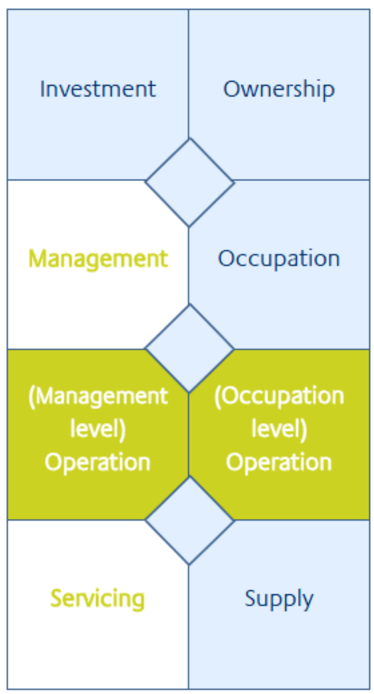

Figure 4. Various levels involved in delivering sustainability in FM .Source: BIFM (2013)

Facilities maintenance and sustainability

Maintenance in facilities management has been classified into categories known as maintenance plans or levels. According to the institute for building efficiency Johnson

Controls institute conducted research in the United States 2012, surveying different levels of maintenance used and it was concluded from this study that adopting an appropriate level of maintenance could achieve energy saving. These maintenance levels are summarized in the following points

1. Reactive or corrective maintenance: This practice is used by 55 percent of US companies and is also known as run-to-fail maintenance, in which systems run till a problem or failure occurs.

2. Preventive or scheduled maintenance: This is periodic maintenance of equipment, generally done as prescribed according to the recommendations of manufacturers. This practice is used by 31 percent of US companies.

3. Predictive maintenance: This practice has been adopted by 12 percent of US companies. This strategy differs from preventive maintenance by resetting and basing maintenance on the original situation of the machine rather than on a preset schedule. Predictive maintenance is considered to be the most cost effective among maintenance levels in the long term, but it does necessitate investments in technology infrastructures up front.

Curl (1999) and Jardni et al. (2006) have highlighted that an estimation of building system energy savings can be achieved from maintenance; they have conducted a few studies that analyze the whole-building energy savings of HVAC system maintenance and other systems. Frankel et al. (2012) have found that the best practices for building operations and maintenance can reduce energy use by 10 to 20 percent in all climate zones in the United States. Conversely, poor maintenance practices are likely to increase energy use by 30 to 60 percent.

Chimack et al. (2006) , Curl (1999) and Jardni et al. (2006) discovered in their studies that having set points of HVAC systems and their schedules, economic operations, ventilation controls and settings can preserve equipment and as a result, the energy. Following a plan to clean the centrifugal chiller tubes showed an energy consumption reduction of 15 percent; this was because the microbes in the chiller tube bundle decreased heat transfer, and a reduction in heat transfer can be compounded by iron disposal.

Chimack et al. (2006) have illustrated that preserving suboptimal refrigerant levels is an efficient energy conservation method, since the efficiency of chillers can suffer if the level of the refrigerant is less or more, and this might lead to energy savings of up to 20 percent. Leaks in the machine result in reduced airflow into the unit, and this in turn reduces the efficiency of the HVAC and increases energy consumption levels by up to 14 percent.

Azizi, Wilkinson, and Fassman (2014) have identified that occupants should be taken seriously when they ask for maintenance or simply require changes. Furthermore, an active FM team should have a practical and proactive help desk to respond and deal with users' complaints, as this is an important factor for achieving energy savings, as mentioned by Levrat et al. (2007). As a whole, management in FM should be proactive and preplanned rather than reactive.

Curl (1999) and Jardni et al. (2006) have exemplified that FM teams should adopt a good maintenance schedule to reduce energy consumption and to enhance the quality of services provided. FM teams must place more emphasis on the whole life cost than on the initial capital cost, particularly when a client is the end user.

The Carbon Trust[2], the Energy Trust and the New Zealand Green Building Council (2011) have determined several key maintenance measurements for equipment and its handling during operation to reduce energy consumption and conserve resources. Also, many researchers, such as Azizi et al. (2014), Brauers (2004) and Li (2013) have mentioned that some practices should be adopted in the following categories:

1. Lights and lighting: Lighting diffusers and shades have to be cleaned or maintained on a regular planned schedule. Blinds and windows must be regularly cleaned, as well.

2. Sensors, such as room sensors, duct thermostats, humidistat, pressure sensors, temperature sensors, and meters should be checked on a regular basis and calibrated according to the Energy management system (EMS).

3. Fine tuning of control systems has to be done during the first year of operation.

4. Energy auditing plans and submeter recording: Submeters of building systems must be monitored and recorded to investigate energy consumption by major building processes. This consists of data collection regarding energy consumption

2 The Carbon Trust is an independent expert partner of leading organizations around the world, helping them contribute to and benefit from a more sustainable future through carbon reduction, resource efficiency strategies, and commercialization of low-carbon technologies.

figures, floor area, and temperature variations. After data collection, readings must be analyzed and interpreted to determine where energy could be reduced.

Building modeling and sustainability in FM

Andrews et .al (2012) argued that sustainability in FM will benefit out of building modeling and simulation since so many parameters could be studied in it , although human behavior is not yet well controlled in building simulation as it is very difficult to predict and involve. Building modeling is very effective in today's' research to minimize the gap between actual energy consumption and simulated one.

Operation and maintenance practices for sustainability

Numerous energy management organizations and institutes have developed plans and guidelines for energy conservation practices during building operation. These organizations are the Carbon Trust (2010), ENERGY STAR (2012) and ASHARE; all of which have set plans to be adopted as practices to reduce energy consumption by FM activities and functions. Additionally, many researchers such as Azizi et al. (2014), Brauers (2004) and Li (2013) have mentioned other practices to be followed. Some of these important practices are as follows:

- Energy schedules must be tested, commissioned and updated.
- Scheduling: Detailed schedules are needed for every building and for different sections since scheduling for only some sections and parts is considered ineffective. According to LEED-EBOM (2009), scheduling techniques must

consist of an equipment runtime schedule, an occupancy schedule and set points for all HVAC equipment and lighting levels. For instance, it is advised to set timing operations to turn off the HVAC around one hour before the end of the working day and to set a temperature of cooling systems between 20 °C and 24 °C.

- Review and edit operating schedule strategies.
- Exterior lighting schedule should be changed according to the season.
- Motion sensor sensitivity and time delay settings must be customized according to the requirement of each individual space
- Submeters must be taken into high consideration by recording, monitoring and analyzing energy consumption. This includes energy cost, temperature settings and surveys for user satisfaction.
- Scheduled cleaning during opening of the building instead of after working hours in order to save energy that would otherwise be consumed if cleaning were to take place during separate hours at the end of the day.
- Switch off the HVAC one hour or half an hour before closing the building after working hours in order to save energy.
- Promote awareness and training for employees and users.
- Try to eliminate user controls so as to standardize behavioral patterns.

- Surveys to be conducted quarterly to identify systems, lights, and equipment in need of maintenance.

- An energy report must contain reasons for an energy increase and recommended plans for additional improvements in energy efficiency. These kinds of reports are used to build historical baselines for comparison of energy consumption throughout a building's lifecycle.

- Documentation must be prepared by the operation management team for facilities maintenance teams, highlighting the best practices for energy management to cure any defaults. Moreover, operation of building systems has to be recalibrated as advised by manufacturers.

Sustainability assessment tools

Al-Yami et al. (2015) and Bushra et al. (2011) have mentioned that sustainability assessment is an up and coming notion and one of the usual questions raised is how tools measure sustainability. Does the assessment tool deliver what it promises to do through its certified buildings? The following section explains possible answers for those questions.

Bushra et al. (2011) stated that since sustainable development has become a catchphrase, numerous approaches and frameworks have been proposed in a mixture of disciplines, ranging from engineering, to business and policymaking. Those frameworks have a partial or limited capability to deal with different issues of sustainability comprehensively. They also lack the flexibility to be used in various disciplines according to an integrated interpretation.

Bell and Morse (2008) have argued that measuring sustainability has always been considered a challenge. This refers to the fact that it requires an assessment of many aspects - those may consist of objectives, assessment criteria and indices. For the purpose of measuring sustainability, performance indicators and indices are derived from several variables to assess the effectiveness of a decision in meeting the needed criteria. These variables can depend on context, conditions, means, activities and performance.

Al-Yami et al. (2015) have illustrated that a lot of well-known assessment tools, such as BREEAM, LEED and CASBEE were not originally designed to suit developing countries, taking into account that most of those environmental assessment schemes developed their criteria before adopting a weighting system. Famous assessment methods such as BREEAM and LEED are not considered to be fully applicable to environmental assessments within the Gulf. This is mainly due to the fact that most of those building assessment classifications and criteria were developed to suit a specific region and its built environment. For instance, in the United States, LEED is used and in the United Kingdom BREEAM is applied. Haapio and Viitaniemi (2008) have argued that even though those assessment tools have been used widely in other regions, proof has been provided that assessed buildings generally do not perform according to their qualified grades.

Al-Yami et al. (2015) have asserted that a weighting system is the main key of any building’s assessment method, however LEED has been criticized for the absence of an adjustable weighting system, since it uses simple 1:1 additive credits. Another significant critique Al-Yami et al. (2015) highlighted is that Gulf countries have one of the hottest and most arid climates globally, with scarce water resources; however LEED has distributed the possible accreditation points for each criterion as listed in table 2. This means that any building can be LEED certified regardless of its planned water efficiency and consumption patterns.

Table 2.Distribution of LEED accredited points. *Source:Al-Yami et al. (2015)*

35 points for energy	26 possible credits for sustainable sites
14 points for materials	Only 10 points for water

Do assessment tools deliver on their promises through certified buildings?

Diamond (2008) has debated the performance of LEED buildings as follows: “Can one demonstrate that these buildings perform differently from other new buildings? Do they use less energy and water and do they provide more benefits to users in terms of productivity and health?”. He continues his argument saying that: Quality is an important consideration in built environments because it determines the functionality and reliability of building services. However, LEED does not take quality into account, since there is no category for this aspect.

Zheng (2013) and Scofield (2008) researches resulted in the following findings: the average energy consumption by LEED certified buildings is actually higher than the corresponding average for US commercial building stock: “This difference is shown to be largely due to the over-representation of ‘high-energy’ principle building activities (PBA’s) such as laboratories and the under-representation of ‘low-energy’ PBA’s such as non-refrigerated warehouses in the LEED building data set, relative to their occurrence in the U.S. commercial building stock.” Scofield has published many papers arguing that there are green benefits to LEED building certification, but primary energy consumption reduction during the operational phase is not one of those benefits.

Actually, there is a need to call for more comprehensive collection and publication of modeled and estimated versus actual energy consumption data. More investigations are recommended to be done in order to prove this using multiple different approaches to provide a clear and accurate understanding of this dilemma (Dimond, 2012).

Energy benchmark methods

Chan (2009) and Monts & Bliss (1982) have demonstrated that the energy benchmark universally known as the Building Energy Index (BEI) is calculated according to the total energy used in a building for one year in kilowatt hours divided by the gross floor area of the building in square meters, expressed in the unit kWh/m^2/year. Another approach to benchmarking energy use is to compare historical energy performance data from previous years with one another and verify an increase or reduction (ENERGY STAR, 2012). BEI data gives operators more choices when deciding how much effort should be taken to reduce energy consumption.

Sustainable university campuses

This section surveys the latest efforts to assess sustainability in higher education. The assessment of campuses identifies and benchmarks leaders and best practices. Moreover, it determines general goals, experiences and methods. The collected data in this section will be used to benchmark energy consumption in the following chapters.

Azizi et al. (2014) have conducted analyses for campus buildings and have provided the following table to compare their electricity consumption. The study had investigated practices in university of Auckland by comparing energy consumption for 3 university buildings. Tables 3 and 4 show the data collected and electricity consumption for this study.

Table 3. Buildings' data of the case study .*Source: Azizi et al. (2014)*

Building	Thomas building (TB)	Owen Glen building (OGGB)	Population health complex (PHC)
Area	4958 m2	74,000 m2	11,338
Storey	4	7	4
Occupants	160	400	300

Table 4. Buildings' electricity consumption. *Source: Azizi et al. (2014)*

Building	TB	OGGB	PHC
Actual energy performance (2011)	239,892.98 kWh	3, 589,548 kWh	369,265 kWh
(2012)	376,631.98 kWh	3,955,666 kWh	381,819.71 kWh
Difference from last year (target)	136,739.00 (57%)	366,118 kWh (11%)	24,468 kWh (4%)

Faghihi (2015) has stated that sustainability in universities creates a proactive leadership atmosphere and good conditions for a sustainable environment. Numerous universities have undertaken initiatives and projects to incorporate sustainability into their own systems. Nevertheless, sustainability is still considered to be a moderately new and innovative idea for most universities.

Over the past 15 years, researchers have demonstrated the great advantages of sustainable university campuses. Stratton (2010) and Weber, Bookhart, and Newman (2010) have agreed that campuses are considered main stakeholders in the community in terms of consuming as well as saving energy, they consume energy by occupying huge buildings - on the other hand they save it by conducting researches to create a sustainable community. Moreover, universities educate people concerned about sustainability who hold energy consumption to be a main consideration too.

Sustainability assessment for universities is a challenging and complex process. Literature recommends that multiple methodologies and frameworks be planned and implemented. Alshuwaikhat and Abubakar (2008), Blumenthal (2013) and Too and Bajracharya (2015)have suggested that any sustainability framework must consider not only the three E’s (Economy, Environment and social equity) as mentioned in the preceding chapter, but also educational performance with the following indictors:

- Courses, training and curricula according to educational bases
- Basic and applied research
- Campus operations

Sustainability approaches adopted by different universities

Researchers have drawn upon several methodologies and action plans to guide campus sustainability. Some have concentrated too deeply on the role of education and integration between curriculums, communities, strategic plans and reality; others have focused on real action plans that have been implemented and results that have been achieved. Weber (2010) compared three universities (Yale, Princeton and Johns Hopkins) in terms of their main attitude towards campus sustainability, these had been placed under two categories: technical approach and academic approach, this reflects the importance of education and training to enhance sustainability, table 5 summarizes those findings.

Elmualim et al. (2009) have illustrated the importance of skills and training provisions, arguing that sustainability education and training should be enhanced to afford the parallel application of effective sustainability structures and processes throughout the construction as well as FM industries as common practice.

Table 5.Campus sustainability plans

University	**Yale**	**Princeton**	**Johns Hopkins**
Technical Approach	Systems and Processes 1. Spotlight on building design, construction, energy and procurement. 2. Integrated waste management and transportation. 3. Landscape and water management.	Resource Conservation 1. Concentration on purchasing, dining, waste management. 2. Building maintenance and management. 3. Water management, which includes potable water, landscaping and storm water.	Stewardship of Natural Resources 1. Focus on energy, storm water, water management, grounds waste, purchasing, and construction.
Academic Approach	Society and Culture 1. Spotlight on curriculum 2. Academic incorporation 3. Scholarships and research 4. Human health, authority and university grounds engagement	Civic Engagement, Education, Research 1. Focus on curriculum, academia 2. Research opportunities for students 3. Communications and the intersection of civic engagement by all	Educational Integration 1. Focal point on integrating the skills, knowledge and ingenuity of students and faculty into sustainability projects

In the following pages, two university plans will be reviewed. Those plans were established for providing a sustainable campus. The Universities discussed are: Wisconsin Oshkosh University and the University of Oregon. Stratton (2010) has stated that each campus has to develop its own framework, strategies and goals to be able to measure its success, accomplishments and failures. Tables 6,7and 8 show the main goals for the University of Wisconsin Oshkosh for the period between 2008 to 2012, targeting energy consumption reduction and renewable energy purchase.

Table 6.Plans to be achieved to reduce energy consumption for the University of WO

Area of Study	Electrical Consumption
Goal	On the whole, reduction of electrical consumption levels in 2005 were20 percent by 2012.
Accomplishments	1. Alternating old, wasteful and inefficient building chiller systems with a central chilled water plant in 2001 and 2006. The major core of the campus would be served by this plant. 2. In 2006, replacing the inefficient old chiller system that served the major dining facility, which is located in Blackhawk Commons.
Result	**Electricity Consumption** A reduction in the annual electrical consumption from 31.5 million kWh to 29.9 million kWh, which equates to 5 percent was achieved by Oshkosh from 2003 to 2006, as illustrated in Figure 5.

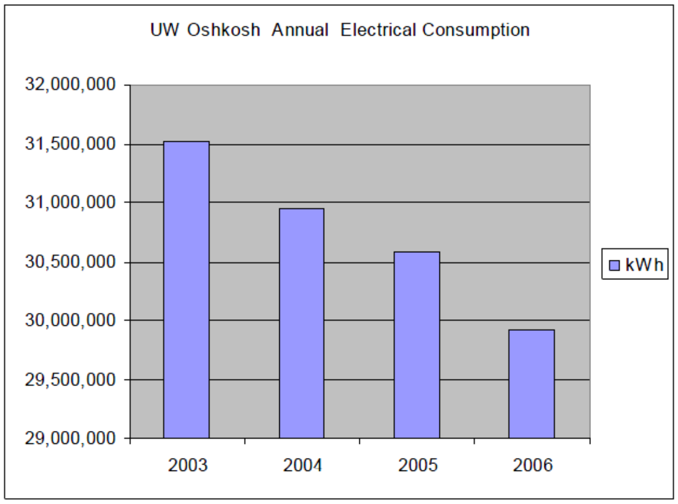

Figure 5. Annual electrical consumption for WO University. Source: Campus Sustainability Plan 2008 - 2012

Table 7.Plans to be achieved to reduce energy consumption for the University of WO

Area of Study	**Campus Heating**
Goal	Lessen annual spending on fossil fuels for heating from 2000 levels by 50 percent by 2012.
Accomplishments	1. In 2002, an environmental controls system, or supplementary baghouse, was added to the heating plant exhaust system. Baghouses are fabric collectors that filter dust particles from dusty exhaust gases. They are considered to be one of the most efficient and cost effective types of dust collectors and can attain a collection effectiveness of more than 99 percent for very fine particulates. 2. In 2004, a new natural gas boiler replaced the existing 40-year-old one to allow a better match of summer steam needs with production capabilities.
Result	Coal Consumption The above listed actions achieved a drop in coal consumption equal to 24 percent over four years. Natural Gas Consumption Over three years, the university achieved a 21 percent annual drop in the burning of natural gas.

University of Wisconsin Oshkosh worked out how to increase renewable energy and this can be seen in figure 6 and table 8.

Table 8. Plans to increase renewable energy

Area of Study	Renewable Energy
Goal	Use renewable energy as a resource for electricity by purchasing it from agencies.
Accomplishments	Launched goals for confident state agencies to meet at least 10 percent of their total electricity needs using renewable energy sources by 2008 and at least 20 percent by 2011.
Result	The target was achieved by replacing 11 percent (as shown in Figure 11) of electricity using renewable resources by purchasing them from an agency.

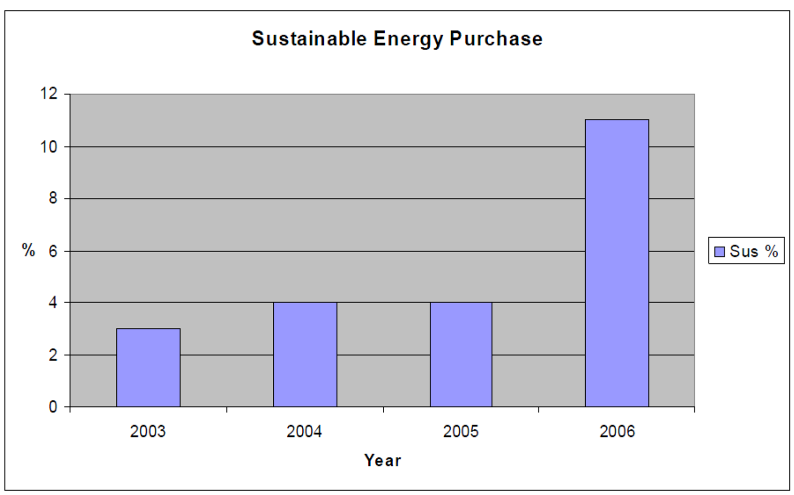

Figure 6.Increasing sustainable energy purchase from 2003 to 2006

Table 9 shows the main goals for the University of Wisconsin Oshkosh from 2008 - 2012 in several areas of water management, targeting a reduced consumption of water.

Table 9.Plans to be achieved to reduce water consumption for the University of WO

Goal	**Water Consumption** Reduce overall water consumption levels by 50 percent from 2000 to 2012.	**Storm Water Management** Reduce the amount of total suspended solids (TSS) coming off the campus by 20 percent before 2008 and 40 percent before 2013 (using the 2006 baseline).
Accomplishments	1. Replaced 1,005 older toilets with 15.5 liters per flush with toilets with 6 liters per flush. 2. Installed low-flow faucet restrictors on sinks throughout the campus. 3. From 2004 till 2005: Replaced natural grass football field at Titan Stadium with an artificial grass surface that requires no irrigation. This effort resulted in estimated savings of 3217.6 m^3 per year. 4. Retrofitted water-cooled systems at Blackhawk Commons with air-cooled systems. 5. Installed five waterless urinals.	1. Developed a storm water management plan (currently in final draft status, awaiting DNR approval). 2. Scheduled semiannual cleaning of parking lots. 3. Conducted regular litter patrols of the campus. 4. Required compulsory installation of silt fences around construction sites.
Result	The first two points listed above resulted in savings of over 41639 m^3 per year. A 35 percent drop in water consumption was the cumulative effect of these efforts between 2000 and 2006. These accomplishments save UW Oshkosh over $100,000 per year in water costs. In 2000, annual water consumption for the campus was 47,542 m^3. In 2006, that annual consumption level dropped to 30,824 m^3.	Actions are still in progress and at most they covered the goals.

The University of Oregon had established an assessment for energy, water and transportation. Metering is the main method that has been adopted to evaluate energy consumption, followed by goals to be achieved based on the metric findings. According to Stratton (2010) the following metrics are used:

Metric 1, submetering, and its goals: Submetering is used to detect the different percentages of energy consumption, such as: meter for HVAC consumption alone and lighting alone ext…

- The main goal to be achieved by 2015 is to increase the electricity submetering percentage to 80 percent of campus square footage (from 61 percent).

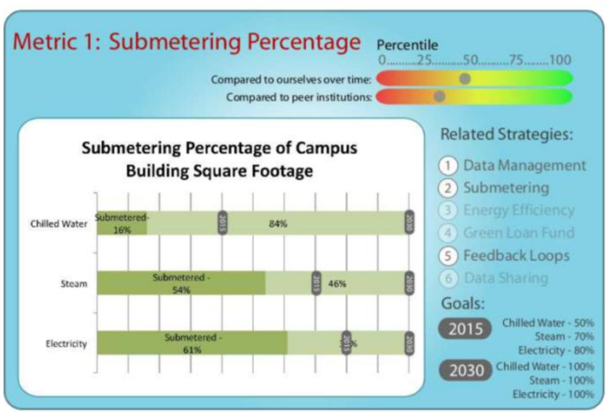

Figure 7.Submetering percentage Source: 2010 UOO campus sustainability assessment

Metric 2, energy use intensity and its goals: Stratton (2010) had reported that EUI measures how much energy a building consumes per unit area over the course of a year. This metric can be calculated for the campus as a whole and for individual buildings as well. Furthermore EUI could be divided to be calculated for separate areas by comparing their areas with their consumption separately. Figure 8 shows that labs are consuming the highest percentage of energy compared to their areas. To add, the percentiles for the university buildings advise that the laboratory, academic and residential campus building categories have the most potential for energy efficiency improvements. The total kWh use per student has decreased over the last decade. In 1993 per capita usage was approximately 3,321 kWh while in 2003 it was only 2,774 kWh.

Goals to be achieved:

- For all University of Oregon buildings, the total energy use intensity will be compacted to 586 kWh/m^2 (65th percentile) by 2015.

- The total energy use intensity for all University of Oregon buildings will be concentrated to 498 kWh/m^2 (90th percentile) by 2030.

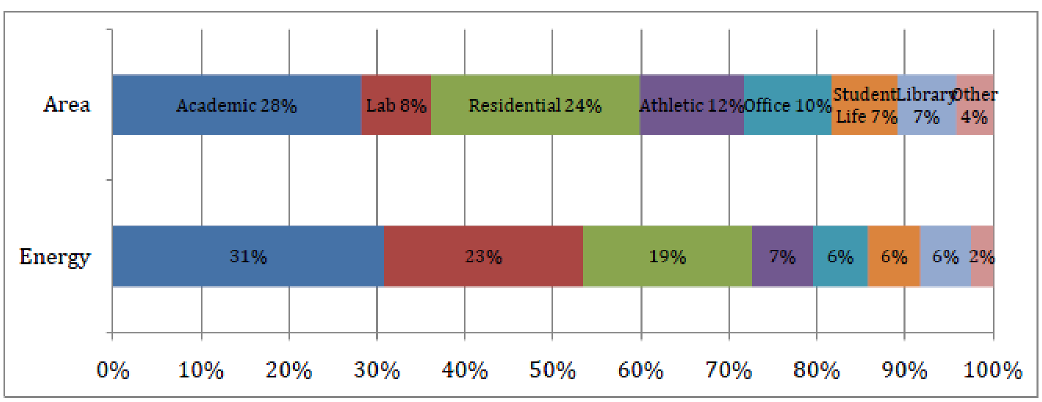

Figure 8. Building area and energy use percentage . 2010 UOO campus sustainability assessment

Metric 3, percent renewable and its goals: OU sustainability plan (2012) had reported that metric 3shows the percent of renewable sources of energy used in campus buildings. Energy data for other institutions is not widely available, which is why the renewable percentage of total energy is calculated for the University of Oregon but not compared to other peer campuses and institutions. The renewable total at present is 20 percent of energy used in campus buildings (mostly from large-scale hydroelectric power).

The goals are as follows:

- By 2015, recommend a target for the university to derive 30 percent of its total energy from renewable sources. This might come not only from replacing nonrenewable energy with renewable energy but also decreasing all energy use from first to last energy efficiency measures.

- By 2030, propose an objective for the university to derive 80 percent of its total energy from renewable sources.

Metric 4, greenhouse gas emissions and its goals: This metric tracks greenhouse gas (GHG) emissions. Emissions concentration is measured in metric tons of carbon dioxide per one thousand gross square feet of campus building each year.

The goals are as follows:

- By 2015, propose a 15 percent reduction (from 2010 levels)

- By 2030, recommend a 60 percent reduction in university GHG emissions intensity

Although the construction of new buildings on campus will add to the university's GHG emissions overall, it is likely to decrease GHG emissions intensity since these new buildings will be more energy efficient than existing buildings. This highlights the importance of capping total GHG emissions, not just decreasing emissions intensity.

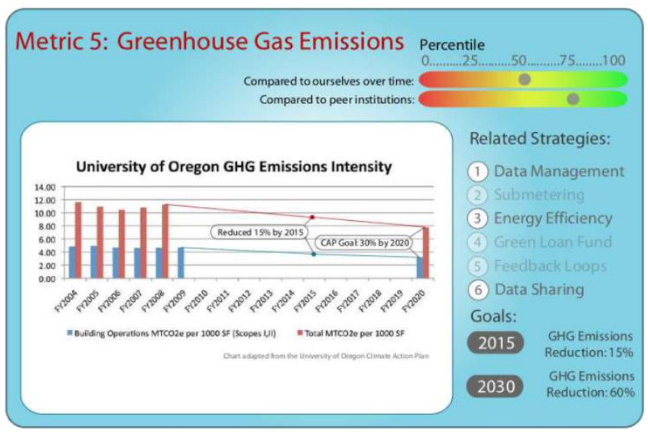

Figure 9. Greenhouse gas emissions. Source: sustainability Assessment 2010 University of Oregon

Metric 5, LEED certified percentage and its goals: To assess how green the Oregon University campus is, this metric determines what percentage of campus square footage is LEED certified. Four percent of the square footage of Oregon University is LEED certified. There are few institutions that have higher percentages.

The goals of this metric are as follows:

- Propose that 10 percent of total university building square footage be LEED certified by 2015.

Chapter 3: Research Methodology

Methods overview

The main objective of this study is to investigate the facilities management industry in Qatar with a more focus on educational campuses, since no previous studies have been conducted in this field in Qatar .Moreover, an analysis of energy consumption data has to take place in this research. This research is located within the interpretative research paradigm , since interview methodology had the starting point of the research and it is used continuously during the whole research to take feedbacks from interviewee regarding case studies, questionnaire and energy consumption analysis. This research targets an investigation of the nature of sustainable facilities management in Qatar and offers a benefit to the industry in the frame of best practice guidance that could be implemented by FM to reduce energy consumption.

Three types of research methodologies have been used in this research. The first is interpretative research which is represented by interviews and considered to be more qualitative. The second is traditional scientific research which is more quantitative, represented by a survey questionnaire and the gathering of energy consumption data. The third also focuses on collecting energy consumption data analysis following the engineering-oriented research approach in which observation comes from the real world and is considered to be empirical.

The first step in this study was a comprehensive literature review of historical and theoretical research conducted in this field and related areas, as well. A brainstorming session was also held to identify appropriate frameworks and possible methodologies to illustrate the link between sustainability and FM.

The second step was to conduct interviews with key experts in sustainability and FM in Qatar to understand the nature of facilities management, sustainability strategies and implementations within facilities management in Qatari organizations. To achieve this, several interviews were conducted with facilities managers and senior executives in the field for major campuses in Qatar. Parallel to that, a survey questionnaire was developed using a systemized process referring to interview answers.

The third step was to test this questionnaire in a pilot version to collect controlled feedback, redevelop and modify the final version of the questionnaire. The fourth step was to conduct the questionnaire in Qatar to analyze respondents' data. Data collection for energy consumption was done in order to calculate the EUI and conduct energy analyses for specific buildings on those campuses. Finally, a benchmark analysis was done to assess the energy performance of the selected buildings. Figure 10 is representing the flowchart of methodologies.

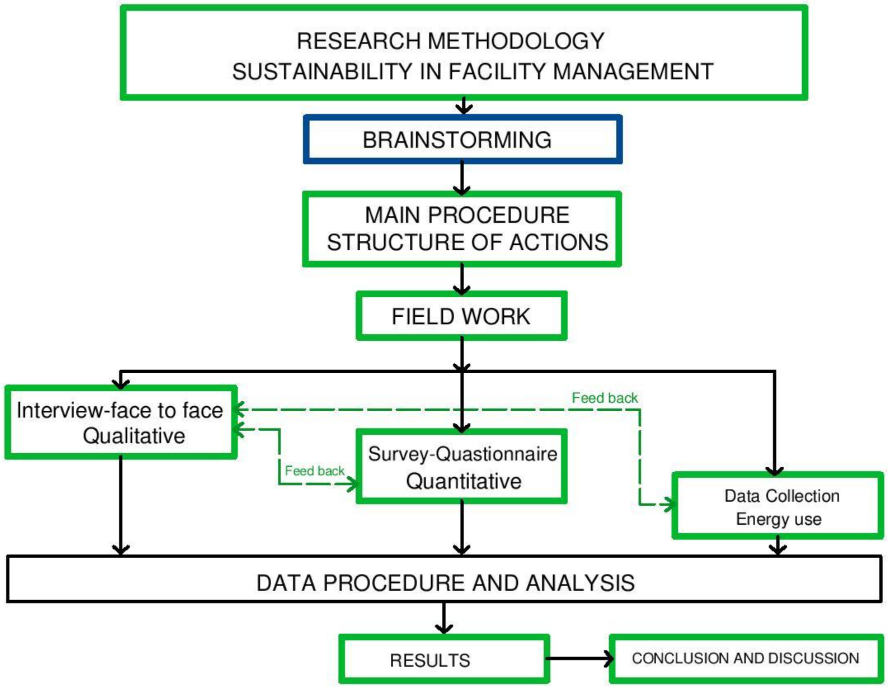

Figure 10. Research methodology

Brainstorming

Brainstorming was completed to identify appropriate frameworks of possible methodologies that could be conducted to determine how a link can be drawn between sustainability and FM. This intended linkage were done through determining sustainability aspects and FM functions, then finding ways to relate them in order to come up with practices that can be adopted to improve sustainability in FM; figure 11 illustrates this link. Moreover, the following list of inquiries was done to be investigated:

1. Energy consumption data and all related information for buildings.
2. Sustainability awareness and training for FM team
3. Involvement of FM in early project stages (design and construction)
4. Strategic planning for SUS FM
5. Sustainability practices and their implementation
6. Barriers to achieve SUS FM and actions to overcome barriers

Once these uninfluenced thoughts were written down, a review of recommendations in the literature was taken to ensure the completeness of these ideas.

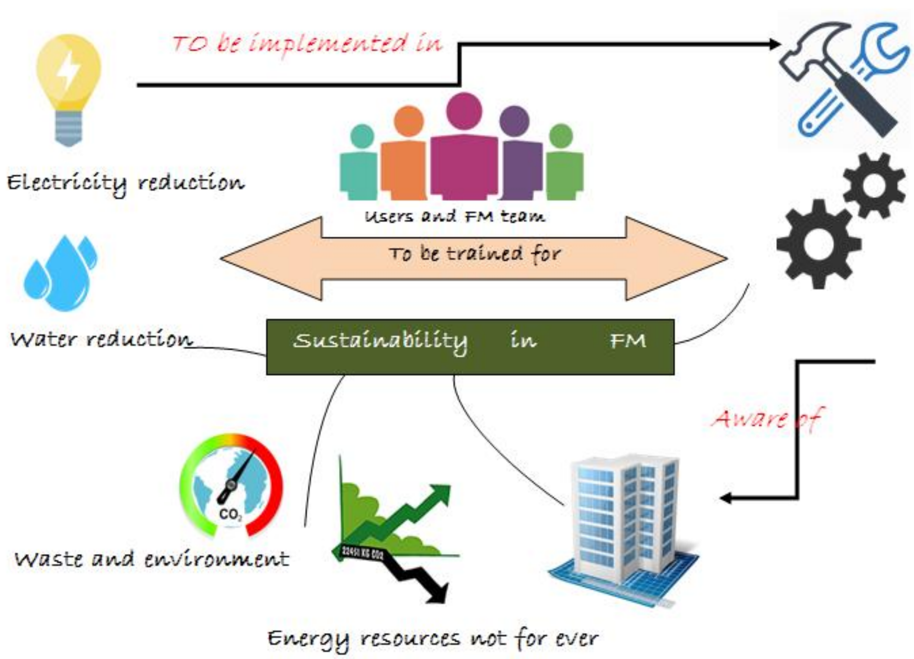

Figure 11.Brainstorming map

Interviews

After the literature review and brainstorming session were done, a series of interviews were planned to be conducted for a group of experts representing FM and sustainability organizations, most to be in management and senior levels. Those interview questions were used to build the survey- questionnaire and to test the convergence of answers that are coming from both sides (interviews and questionnaire) in order to understand the condition of FM in Qatar.

Considering that interviews are generally easier for respondents, particularly if the requirements are opinions and impressions, the interview approach was thought best as a major data collection tool. The interview approach as a qualitative data collection tool is preferred in this study, since no earlier research has been done in this field in Qatar, so there is no available data in this sector. As a result, interviewing key personnel in FM will provide insight into the FM environment. Furthermore, these interviews will serve as a reference when investigating real practices on the ground.

Interviews are a credible way to collect empirical information, since they take into account direct observations of body language. Interviews also offer more time to ask for details through conversation. In simple words, with good communication skills, interviews are considered to be an efficient methodology for data gathering. Kvale (1996) has mentioned that qualitative research interviews aim to describe the meanings behind central themes regarding a certain topic. The major role in interviewing is to understand the meaning behind what interviewees say. Interviewers are able to derive more in-depth data and information about a subject. Moreover, interviews are considered to be useful when following up with particular responses to questions and surveys as an additional investigatory tool (McNamara, 1999).

Preparing Interview questions

Questions have been prepared after referring to previous interviews done by researchers in prior studies; those questions were collected from the literature review stage and act as a reference. Refer to Appendix A for questions collected from earlier research papers.

Interview questions have been designed to answer the research questions and to meet the study objectives. Furthermore, they were planned to scan the FM environment in Qatar Interviewers' questions comprised two types:

1. The general interview guide approach, the intention was to ensure that the same general areas of information were gathered from each interviewee. This offers more concentration than a conversation, although it still allows a degree of flexibility and adaptability in taking information from the interviewee.

2. In standardized, open-ended questions were asked of all interviewees. This approach facilitates faster interviews that can be more easily analyzed and compared.

Interview questions have been classified under certain categories to be brought under investigation, in order to facilitate analysis. Those categories are explained in the following points and are shown in figure 12.

Figure 12.Interview questions categories

Category 1: Organization sustainability strategic plan

This category aims to investigate the intentions of an organization to adopt and implement sustainability plans. More specifically, it aims to investigate to what extent SUS FM is being considered and understood by facility managers and key planners. These questions are open ended and are listed as follows:

1. Is there sustainability custody at your organization? Is it a key objective for your organization?

2. How might you achieve it?

3. Is there a separate department in your organization for sustainability? If not, why? Is there an intention to establish one?

4. What aspects do facility managers identify as the relative qualities of sustainability?

5. Was sustainability reported upon within your organization's last annual report?

6. Do you create metrics that directly correlate with sustainability practices?

7. What kinds of difficulties are you dealing with when implementing sustainable practices?

Category 2: Involvement of FM in early project stages

The aim of this category is to identify the integration between FM teams and design/construction teams and to what extent this could benefit sustainability. Questions are focused on FM involvement in prior stages of building operations and the importance of this involvement is asked about. If interviewees are not working in FM, they were asked if they involved FM in early stages of the project and what the importance of this involvement was. These questions are listed below:

1. Is FM involved in the design phase? Has it significantly increased in today's practice?

2. What are the pros and cons of early involvement of FM in the design/construction phases?

3. How can early involvement affect sustainability?

4. What are the obstacles to early involvement of FM during the design/construction phases?

5. How can one encourage FM involvement?

Category 3: Accumulating experience versus sustainability

This category aims to investigate the relationship between experience within a company and its adoption of sustainability practices. Since sustainability practices are considered to be advanced practices, they require experience within a company.

1. How many years of experience do you have, and how many at your current company?

2. Do you believe the time a facilities manager has been in his or her position at the same organization can affect sustainability practices within that organization

Category 4: Green accreditations and buildings

The aim of this category is to determine the concerns and interests of interviewees regarding green accreditations, personally and for their buildings. Specifically, it investigates to what extent interviewees can determine the importance of those accreditations.

1. Are there any LEED or GSAS buildings on your campus?

2. If so, do users know about them?

3. Could you demonstrate how they perform differently from other buildings?

4. Are FM team certified with green accreditations and/or training?

5. What kind of accreditations and/or training do they have?

Category 5: Sustainability awareness and knowledge

This category examines the level of knowledge, education, and training delivered or intending to be delivered to raise stakeholders' awareness about sustainability.

1. Are there sustainability training sessions or workshops for the FM team to enhance their understanding about sustainability? How many per year?

2. Could you please rank the following aspects according to their importance in achieving sustainability?

   a. Energy efficiency

   b. Site quality

   c. Water efficiency

   d. Materials management

   e. Waste management

   f. Cultural aspects

   g. Indoor environment quality

3. Is the department of FM conscious of users' awareness regarding sustainability?

4. What programs have been established to serve this objective (workshops, surveys, feedback collections, booklets, brochures, meetings with key users etc.)?

5. What is the importance of people's awareness in terms of delivering sustainable practices?

Category 6: FM services and maintenance

The aim of this category is to examine levels of services, maintenance and practices to serve sustainability during building operation.

1. Are any buildings prioritized over others in terms of services?

2. What potential problems could FM find?

3. What levels of maintenance are adopted in your organization?

4. How could preventative maintenance impact sustainability?

Interviewee selection

Nominated interviewees were planned to have long experience with different backgrounds, ranging from mechanical, electric, plumbing (MEP) to architecture and civil services. Each interview was planned to be scheduled by phone or mail and interviews were planned to be conducted face to face in the interviewees' offices for about one hour. Open-ended questions were conducted to solicit feedback and unanticipated responses as well as to give free room to answer, since there is no specific range of answers to choose from. The open-ended questions gave respondents a chance to share and communicate their specific experiences.

Questionnaire

The interview responses and answers were planned to provide a holistic image of the FM industry in Qatar from a management perspective. The following step to offer more technical data was to be a questionnaire that had to be conducted in order to gather more detail by involving a bigger sample. Participants were to be from different organizational levels and had to involve engineers, supervisors and technicians.

Questionnaires have a lot of advantages over other methods of data collection, especially online questionnaires, because they save time in comparison with interviews. An online questionnaire is easily distributed, collected and saved using a website. It also offers people more freedom to answer and tell the truth anonymously. This is an important point to be taken into account, especially in an environment that lacks transparency. In addition to all of the above reasons, participants have more choice in terms of choosing an appropriate time to fill out the questionnaire by following a link at their convenience.

Building and designing the questionnaire

Questions were planned to facilitate the gathering of needed information to serve the objectives of this research. The questionnaire was structured to start with a broad span of general questions, secondly it was to ask about the FM industry and sustainability and then to ask more narrowly about SUS FM using more technical questions. The diagram below in figure 13 illustrates the structure of the questionnaire.

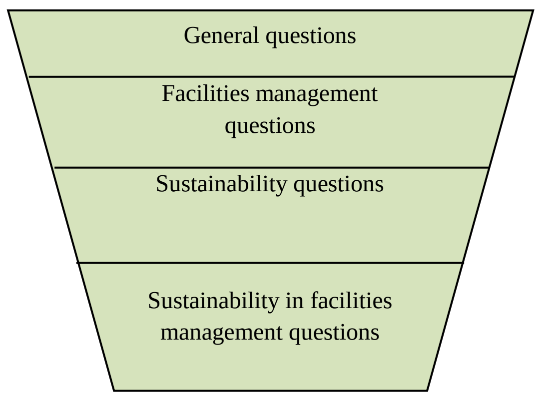

Figure 13.Questionnaire structure

The questions were planned to be a mix of both open- and closed-ended questions. They relied more on the closed-ended questions as there was a need for specific answers such as ‘yes’ or ‘no’, ‘agree’ or ‘disagree’ and multiple-choice questions. Moreover, scaling questions were designed to collect certain data. Some questions were planned to be asked twice in different ways to reduce overall participant bias and better a pinpoint on participants’ true opinions. An “I don’t know” option was added to numerous questions in case those respondents did not have an honest opinion about the question or could not provide an exact answer. This could help to avoid the collection of inexact answers and therefore biased results. The questions were classified according to groups which are shown in table10. For a full version of the questionnaire, refer to Appendix B.

Table 10. Survey questions

General information	Organization sustainability plans	Involvement of FM from early stages of a project	Green Accreditations
Organization / Company	Is there a separate department in your organization for sustainability or energy and environment?	Is there an involvement of FM team from the design phase?	Do you have any Green accreditations? please select the applicable one:
Years of experience in current company Years of experience in sustainability	Are there sustainability practices at your organization / is it recently implemented?	What is the best stage of a project for the FM personal to be involved in?	How many LEED buildings do you have in your campus or intended to have within 2 years?
Email (optional) level of education Degree Back ground	Do you have annual sustainability reports?	Select the phase that you as an FM personal involved in current projects that you are working on:	

Sustainability knowledge	department in which you are working in	Maintenance questions	Sustainability practices
Did you receive any training and /or workshops regarding sustainability in your current organization? Would you be interested in being trained in sustainability practices or in sustainability on Facility management for your work?	Carpentry services Cleaning services Waste management Services Electrical services HVAC services Plumbing services Civil services Others	How regularly you are checking and or inspecting the following (as a preventative maintenance plan)	What do you think are the main obstacles for implementing sustainability practices?

Energy consumption and benchmarking

Chan (2009), Monts & Bliss (1982) have demonstrated that the energy benchmark universally is the Building Energy Index (BEI) (known also as EUI)is calculated using the total energy used in a building for one year in kilowatt hours divided by the gross floor area of the building in square meters, it is expressed in the unit kWh/m^2/year. Another approach to benchmark energy use is to compare historical energy performance data from previous years to verify an increase or reduction (ENERGY STAR, 2012). BEI data thus gives operators choices when deciding how much effort should be made to reduce energy consumption, as certain costs are involved if ambitious energy targets are set.

Why benchmark?

Benchmarking is considered to be an effective and valuable approach for energy management as it gives an analysis of the collected. Furthermore it tracks differences between standards and recent applied practices in an organization. As mentioned in the previous chapter, multiple universities had conducted energy recording and benchmarking to achieve the following

1- Comparing current consumption to that in prior years

2- Trying to give reasons for an enlargement in consumption

3- Planning and implementing strategies to reduce consumption.

Benchmarking assists with the following:

- Evaluating present performance
- Encouraging a facility to improve
- Recognizing best practices
- Determining proper goals
- Ranking and leveling facility performance

Approaches to benchmarking

The following are approaches to benchmarking on campus:

- Benchmark a building across different years of performance and consumption, using previous years as a baseline
- Benchmark using several buildings on the same campus
- Benchmark using similar buildings off campus
- Benchmark by comparing buildings to a national database such as ENERGY STAR's Target Finder

In this research, various sources were used to collect the required data to study the energy consumption performance of several educational campuses in Qatar. As a group, the gathered data could be a first step in populating a database consisting of the names of campuses and their energy consumption across recent years (2010–2016), starting from 2010 because a lot of buildings are new and campuses have begun recording their energy consumption only recently. This database is a good platform through which to record energy performance data, facilitate benchmarking, and exchange experiences to find best practices. Databases were organized by campus, by building, and by year.

Table 11.Required data to be collected for benchmarking analysis

Required data to be collected for benchmarking analysis	Year of construction and commencement of operations
Building type and name	Utility readings and records
Drawing plans	Energy report
Occupation and number of users	Type of HVAC system
Building area	Any green accreditation (GSAS, LEED)
Building function	

Occupancy observation using a behavioral map

Since the data for number of occupants was not available in FM departments or any other campus departments solicited, the researcher planned to estimate this number by implementing an occupancy observation behavioral map. This method relies on field observations conducted by the researcher to record the number of occupants in a space. This is mainly done by counting and recording the occupancy according to a specific time and place, in the floor plan. University fact sheets were also gathered to determine the number of students in each college; this assisted in evaluating the number of occupants.

Chapter 4: Data Collection Procedures

Introduction

After the list of methods and tools was finalized, it was time to search and collect all of the required data and information. This development required an extensive amount of time and effort, although it provided the opportunity to work with diverse campuses and FM teams. Firstly, the researcher set aside the main lists of contacts from whom adequate information could be gathered. This initially resulted in a list of 41 contacts. Secondly, each person was contacted by email with a clear yet concise explanation of the project, its importance and the requested information. The third step was the monotonous but pleasing process of maintaining communication with those contacts to make appointments for interviews and gather data in soft and hard copies. Thirty respondents agreed to meet in person, which required more work on the part of the researcher but also resulted in superior responses and valuable connections.

In this study, the employment history of the interviewees ranged from 7 to 25 years in the industry. As a result, a total of 20 industrial and FM experts were interviewed. The percentage of their working backgrounds is shown in Table 12, Percentages of participated organizations shown in table 13.More details about their distribution is illustrated in Table 14.

Moreover, the respondents addressed many inquiries and offered more data regarding the field. Above all else, some answers opened the door for further investigation of technical issues.

Interviews findings

For this study, interviewees were selected to represent two significant sectors in the field, the first being different sustainability and green organizations adopting sustainability programs and initiatives, the second being the FM of several organizations. Participants were the key personnel in FM teams across multiple campuses, especially education campuses which is the main focus of this study. The sample for these interviews was identified using a snowball sampling approach. A target of 20 individuals to be interviewed was determined with consideration that the number of education campuses is limited between two large campuses (QU and QF). The interviewees participated in a survey questionnaire phase and provided iterative responses.

Table 12.Backgrounds of interviewees

Backgrounds of interviewees			
Architecture	Mechanical	Electrical	Civil
20%	25%	35%	20%

Table 13.Percentages of participated organizations

Percentages of participated organizations			
QU	QF	Aspire	Others
45%	25%	20%	10%

Table 14.Detailed data of interviewee

Position	Background	organization	Years of experience
		Aspire logistics	
Facility advisor	Civil Engineering	Aspire logistics-FM	More than15
HVAC engineer	Mechanical Engineering	Aspire logistics-FM	10 years
MEP –supervisor	Electrical Engineering	Aspire logistics-FM women club	7 years
Senior electrical Engineer	Electrical Engineering	Aspire logistics-FM women club	10 years
	Qatar university QU		
Project manager	Civil Engineering	Qatar university –FM team	7 years
Project manager-sustainable engineer	Architecture	Qatar university –FM team	11 years
Project manager	Civil Engineering	Qatar university –FM team	7 years
Electrical supervisor	Electrical Engineering	Qatar university –FM team	12 years
Electrical Engineer	Electrical Engineering	Qatar university –FM team	12 years
Mechanical supervisor	Mechanical Engineering	Qatar university –FM team	7 years
Section head (electrical systems)	Electrical Engineering	Qatar university –FM team	3 years
Manager of Affairs	Civil Engineer	Qatar university –FM team	More than 20 years
Mechanical Technician	Mechanical Engineering	Qatar university –FM team	10 years
	Qatar Foundation QF		
Senior Electrical Manager	Electrical Engineering	QF -FM	11 years
Planning and Logistics manager	Electrical Engineering	QF -FM	More than 15 years
Operation manager	Mechanical Engineering	QEERI	10 years
Head of sustainability	Architecture	QGBC	More than 20 years
Research specialist	Architecture	QGBC	More than 20 years
	Others		
Facility manager	Mechanical Engineering	QIPCO	More than 20 years
Environmental and sustainability manager	Architecture	Lusial	More than 20 years

Category 1: Organization sustainability strategic plan

Responses showed that most organizations have started adopting sustainability practices within the past two years and not before. However, when asked for a documented sustainability plan, interviewees lacked a clear vision for real studied and documented policies and strategies. As a result of this, there has been no regular monitoring and controlling of energy consumption. Some of the organizations are setting goals to gain regional and international sustainability accreditations such as GSAS and LEED, and this refers to the background of having accredited buildings under an international or regional umbrella and standards.

Most of the organizations listed in Table 13 do not have a separate department of FM for sustainability or for energy and the environment. The only two organizations that had established a separate department responsible for this issue were Qatar University and Lusial. QU had recently (in 2015) established the Department of Utilities and Sustainability because there was a need to follow up with consultants regarding the LEED and GSAS accreditations of buildings, as mentioned by the interviewed participants. The consultants' work becomes more accurate and other accreditation points can be gained when the consulting work is supervised and coordinated with QU. No sustainability reports were found, since the department is not yet fully operational and has not yet been established for one year at QU. Aspire and Lusial City have those reports, but with limited data about energy plans and consumptions.

Metrics are directly correlated with sustainability practices referring to general and standard metrics such as LEED. However, those organizations have the intention to encompass their own special parallel policies for sustainability.

Category 2: Involvement of FM in early project stages

Involvement of FM in the design phase is said to be rare and limited. Construction/design teams do solicit some important and urgent feedback from FM in new buildings under construction, however. Aspire zone and Aspire logistics had the best involvement, since some of the FM team personnel had witnessed the construction phase and been part of the project from the early stages. Although early involvement of FM didn’t reach the integration level, interviewees said that it was increased in today’s practices and expected to develop more. Moreover, participants agreed on the importance of this involvement and mentioned some pros of early involvement of FM:

- Early involvement leads to reduced construction time and fewer changes to orders and costs, as well.
- Different entities understand responsibilities across all parties, which leads to a reduction in time for over handling after project completion.
- Direct, fast and easy operation and maintenance is achieved.
- Several pieces of equipment and fixtures considered to be energy efficient are monitored and understood by the FM team if they are involved from the beginning of the project.

- MEP construction teams are able to get practical advice from the FM team regarding the best equipment for efficient performance. Moreover, the FM team provides updated data about spare parts with better and quicker performance.

- The FM team can easily connect with suppliers and subcontractors if they are involved from the design/construction phase.

Obstacles to early involvement were listed by participants as follows:

- The nature of the construction industry is that things need to be rushed and projects are mostly behind schedule since a lot of parties are involved. These include the owners, contractors, subcontractors and consultants. As such, adding the FM team further complicates the communication network.

- Teams often experience a lack of knowledge, coordination and cooperation.

- Projects experience budget limitations and high initial costs.

- Teams lack an understanding of the integration process between design/construction and operation.

Category 3: Accumulating experience versus sustainability

All participants stated that the time period a facilities manager has been in his or her position for the same organization can affect sustainability practices within the organization, as the manager develops knowledge and a sense of belonging and is therefore able to figure out details and understand potentials to enhance sustainability. If a manager has accumulated 10 years or more in an organization, he or she will grow with that organization. In other words, there is a direct correlation between experience in an organization and implementation of sustainability practices.

Category 4: Green accreditations and buildings

Investigating the number of green accreditations gained by FM teams and their buildings is an imperative issue as it reflects the interest and attention from the FM industry regarding sustainability in one way or other. On the other hand, it measures the importance FM places on sustainable buildings on campus. The interviews have revealed an interest in sustainability practices among FM teams, but there is a lack of clear planning to gain the best knowledge.

Most interviewees do not have green accreditations. Only two FM personnel working for QU had green accreditations, one of whom was a mechanical supervisor and the other a project manager. Both had LEED AP design and construction certifications.

The Aspire campus does not have any accredited buildings, neither by LEED nor by GSAS. Qatar University's campus has one project accredited by LEED for design and construction; this is the housing project, which has almost finished being constructed and will be operated soon. Another three existing projects are to be certified by LEED for operation and maintenance are:

1. The women's activity center building
2. The women's science college
3. The central service unit building

- A lot of other GSAS buildings are represented on the QU campus. Figure 14 illustrates the Green accredited buildings at the studied campuses. For the list of certified LEED buildings and registered ones in Qatar, see Appendix C.

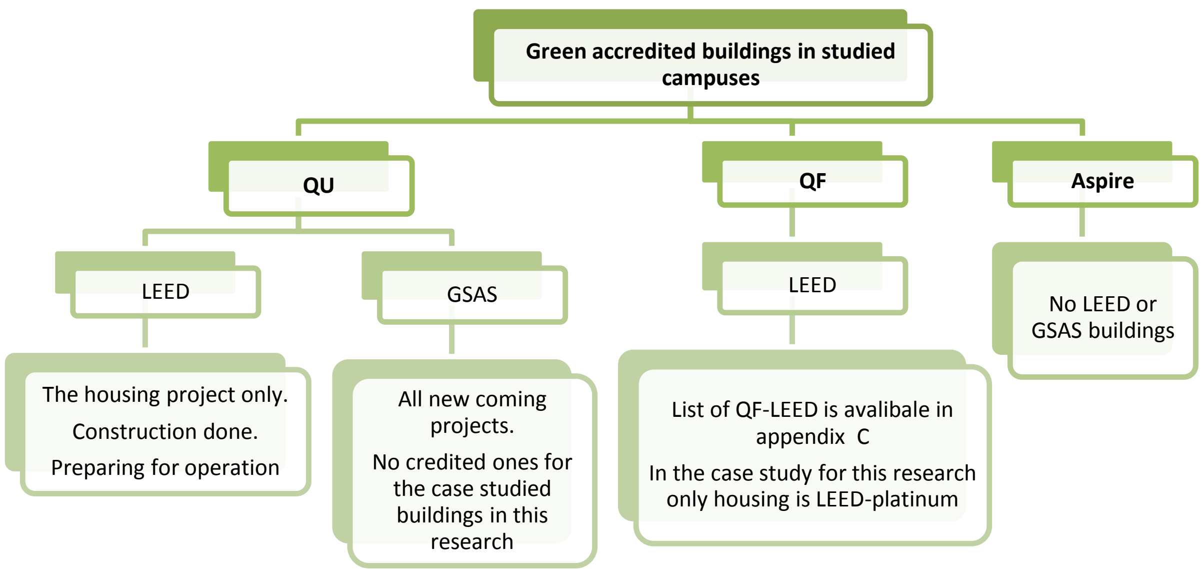

Figure 14.Green accredited buildings in studied campuses

The participants that were interviewed were asked the following question: 'Could you demonstrate how LEED and GSAS buildings perform differently than other buildings?' Their answers are summarized briefly in the following points:

1. These buildings consume less energy if operated and maintained well. HVAC especially, if not maintained and cleaned well will consume a lot of energy even if the building is green certified.

2. They use more friendly materials, such as FSC wood and CFC-free products.

3. A comparison of GSAS to LEED reveals that GSAS concentrates on glass and windows and natural ventilation.

4. LEED and GSAS Buildings should:

5. (1) Have windows that give natural ventilation for three months per year or (2) install a double mixing box (economizer) to reduce energy consumption (none installed at QU).

6. Sustainable buildings may not perform well because of the following:

    a. The concept of sustainability follows traditional ways, not an integrated way.

    b. There is no deep understanding of sustainable concepts and practices. They are adopted mostly when renting buildings to big corporations for the purpose of gaining a good reputation.

    c. People tend to attain green accreditations without giving actual weight to real green practices.

    d. Maintenance plans are not implemented efficiently.

    e. There is no real integration of the whole team, starting from the construction team and ending with the FM team.

    f. All parties are not involved in the design stage.

    g. The nature of the construction industry is that processes must be done quickly, so involving the FM team is considered to be time consuming.

h. In general, MEP personnel are considered to take a supplementary role, not an essential role, in design and construction.

Category 5: Sustainability awareness and knowledge

Interviewees were asked to rank several sustainable aspects according to importance from their perspective and knowledge. Table 15 gives a brief analysis of the results and shows the ranks of sustainability aspects. Interviewees were asked to give grades from 1 to 7 for each aspect according to their importance, where 7 considered to be the highest and 1 the lowest. The score for each aspect is calculated according to the formula: X * N = S, where X equals the aspect grade and N equals the number of interviewees who gave this grade. Table 15 shows the resulting ranks according to the given grades.

Table 15. Sustainability aspects

Aspect to be scored	Total score
Energy efficiency (ranked most important by all interviewees)	20 * 7 = 140
Water efficiency	20 * 6 = 120
Waste management	5 * 5 = 25
	10 * 4 = 40
	5 * 3 = 15
	5 * 2 = 10
	Total = 90
Indoor environment quality	10 * 5 = 50
	5 * 4 = 20
	5 * 3 = 15
	5 * 2 = 10
	Total = 95
Site quality	70
Materials management	85
Cultural aspects	124

The final rankings, from most important to least, were as follows:

1. Energy efficiency

2. Water efficiency

3. Cultural aspects
4. Indoor environment quality
5. Waste management
6. Materials management
7. Site quality

FM departments are generally not holding workshops or any other training sessions to raise awareness for their teams regarding sustainability, all except QF who held a few sessions regarding BMS that could serve sustainability. FM departments are not giving much thought to direct interaction with users, they are only promoting user awareness through signage and emails. No other approaches such as brochures, booklets, workshops etc., are used except for some few publications.

Although the means of contacting users is not efficient and there are no programs to gather them, FM teams are in agreement on the importance of user satisfaction and trying to create channels to reach them. What can be concluded from this is the need to create appropriate programs for end user awareness. The role that the users play in terms of reducing resource consumption is said to be limited, as most interviewees insist that the systems are fully automated and adjusted so users cannot intrude upon energy consumption.

On the other hand, other interviewees believe the behavioral patterns of users can greatly affect consumption through some practices:

1. Reducing misuse of a building.

2. Reducing resource consumption, which results in a reduction of waste and better waste management (water, paper, tools and toilets).

3. Closing doors and windows to save energy.

4. Taking the initiative to turn off lights.

5. Taking the initiative to tell responsible people when water leaks happen, even small leaks.

6. Raising AC temperatures, since a lot of people ask for low temperatures of 18 °C to 19 °C and this requires higher energy consumption, when comfortable temperatures are actually between 22 °C and 24 °C.

Category 6: FM services and maintenance

- Are any buildings prioritized over others?

All buildings are treated the same. Only the backup servers (electricity) are prioritized. While doing replacements or retrofits that apply replacements, the ones with the best economic feasibility are prioritized.

- What potential problems could FM find?

Transportation problems, because there is no urban connectivity for the campus.

- What levels of maintenance are adopted in your organization?

Preventative, reactive and corrective.

- How could preventative maintenance impact sustainability?

If HVAC is not regularly checked and cleaned, this reduces the efficiency of equipment leading to more energy consumption. If dust enters and is not cleaned using chemicals to get rid of bacteria, a blockage may occur, partially leading to a need for more power and energy for the equipment.

HVAC maintenance is done according to the manufacturer's recommendations catalog. Some types of filters are changed while others are cleaned. The HEPA filter and back filter are changed, whereas the pre filter is cleaned - cooling towers are also cleaned.

- What activities consume energy and resources?

HVAC, lighting and swimming pool heating.

- What problems lead to an energy increase?

Misuse such as open doors and windows and setting of low temperatures (18 °C to 19 °C).

- To what extent does the number, type of space or equipment affect energy consumption? Is there special care for buildings after three years?

- What practices have you adopted to decrease energy consumption?

HVAC absorption technology; automated switch on and shutdown for buildings operating from six a.m. to eleven p.m.; photo cells (sensors) for exterior lighting; change of lighting fixtures from old fluorescent ones and others to LED and electronic ballast; change of water heaters (swimming pool), as the older one was consuming a lot of energy; approval of the use of solar panels for external lights (funding issues); and installation of multifunctional digital meters.

Other points: New structures for organizations

Before, the building operation department (BOD) was more centralized, and everything was in one place, but now FM comprises different departments and managers or even head sections, which are less centralized and better coordinated. As FM is not always involved with new projects. One respondent mentioned that FM is involved, taking feedback for the current systems. Contractors change according to the contract duration, and this is beneficial because after some time personnel and teams are not maintained as they should be. High initial costs are one of the largest obstacles when implementing sustainability practices.

Testing the survey - Questionnaire first round

In order to get controlled feedback from respondents and to observe any unusual trends in the data, a pilot questionnaire was deployed prior to the use of the final questionnaire. This was done on a small number of potential participants of the same sample as was used with the final questionnaire. There was thus a first round and a second round when collecting data from the questionnaire; the first round was conducted as a pilot survey using ‘Kwik Surveys’, an online website and was sent to 25 participants (20 of them were interviewees in the interview stage), 11 respondents filled out the survey and gave their feedback using an additional means of communication (face to face, email or phone).

The respondents’ feedback was taken into consideration to rebuild and edit the final version of the questionnaire to launch round two. The following points explain the respondents’ main comments and feedback for the questions and the actions taken during editing.

For Question 12 shown in figure 15 that is asking about the department in which the respondent belongs to there were no respondents from the following departments: cleaning services, waste management services and civil services. This means more focus was needed in those categories since their numbers in FM were limited and the researcher had to encourage them to follow up and get responses in the second round. The following pie chart in figure 15 shows the distribution of participants according to FM departments.

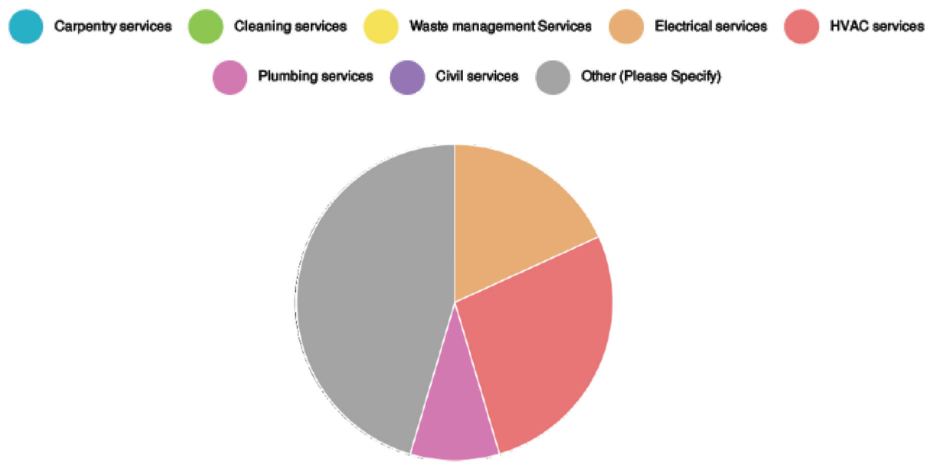

Figure 15.Distribution of participants according to FM departments

For the following question, “Would you be interested in being trained in sustainability practices or in sustainability in facilities management for your work?” the choices were ‘yes’ or ‘no’ as figure16 illustrate. There was feedback from one participant that the scale was very limited and that there should be more choices than ‘yes’ or ‘no’. In round two, one more choice was added: which is: ‘somewhat’.

Would you be interested in being trained in sustainability practices or in sustainability on Facility management for your work?

	Yes	NO	Standard Deviation	Responses
All Data	10 (91%)	1 (9%)	4.5	11

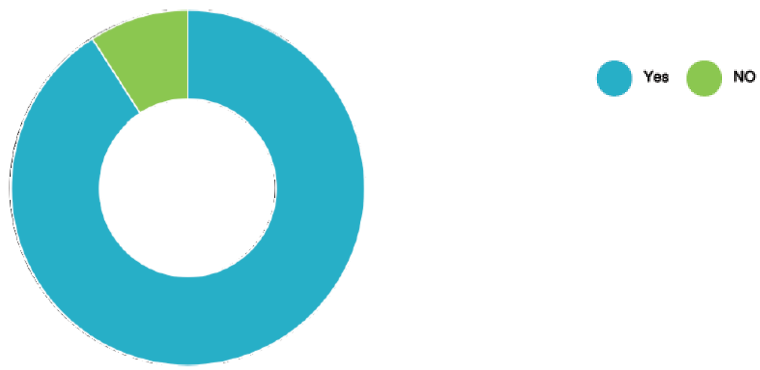

Figure 16. Interest of taking training in sustainability

The question “How many LEED buildings do you have on your campus or intend to have within two years?” reflects a lack of knowledge from FM teams regarding the accreditations of LEED buildings. Since most respondents were from QU, many of them answered “I don’t know”, although QU already has one LEED project and another three existing in the commission stage. One engineer answered this question with more elaboration, as shown in figure 17.This finding gave a hint for taking more consideration when asking about the number of accredited buildings as not all engineers will have the accurate answer and this reflects the lack of involving the whole team in sustainability issues.

	No LEED buildings	1	2-4	4--6	Other (Please Specify)	Standard Deviation	Responses
All Data	7 (70%)	0 (0%)	1 (10%)	1 (10%)	1 (10%)	2.53	10

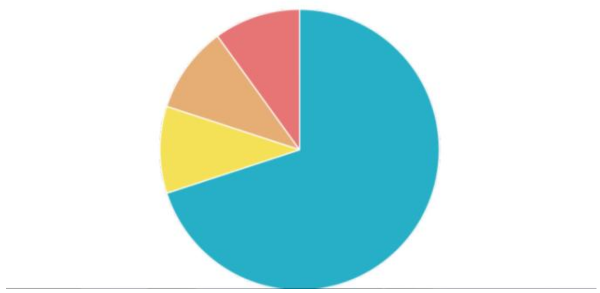

Figure 17. Percentage of green accredited buildings

The question “Do you have any green accreditations? Please select the applicable one” highlights the percentage and number of participants that have green accreditations in FM see the bar chart in figure 18.

DO you have any Green accreditations? please select the applicable one:

	NO	Yes ,LEED, GA Acredited	Yes,LEED, AP Acredited	Yes,GSAS	Other (Please Specify)	Responses
All Data	6 (60%)	2 (20%)	1 (10%)	1 (10%)	0 (0%)	10

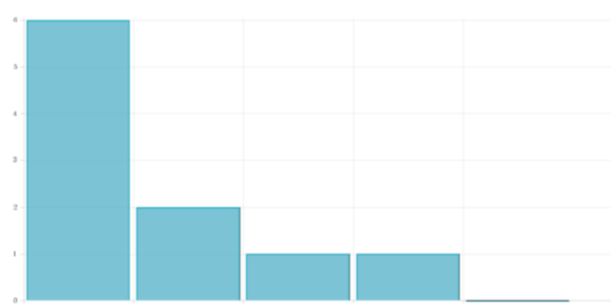

Figure 18.Bar chart for accredited personals

In figure 19 the radar chart shows the importance of sustainability aspects as classified by respondents, energy efficiency and water efficiency recorded the highest two scores, and site quality recorded the lowest - whereas cultural aspects ranked fifth. The way of ranking the aspects in this question lacks accuracy, since the same score could be given more than one time for different aspects. For instance, a participant could give a score of 4 for three aspects or even more (energy efficiency, water efficiency etc.). As a result this question could be edited and used in another calculation framework in round 2, in order to give more accurate results.

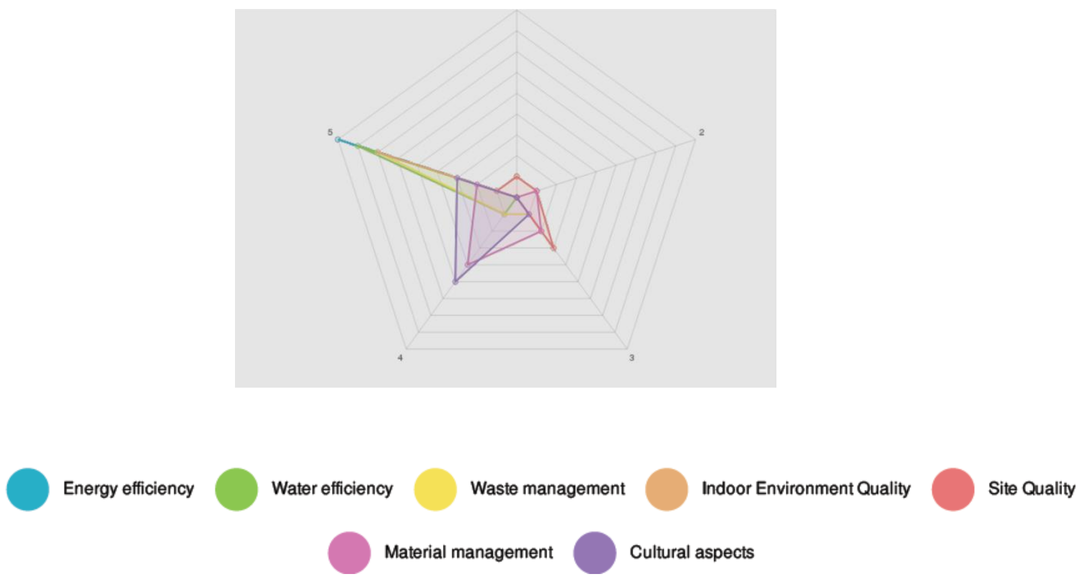

Figure 19. Sustainability aspects ranked according to the most important one

For the following question, “What HVAC system is used in your building/campus?” 2 answers were provided as presented in figure 20, a feedback was given by a mechanical engineer that a lot of systems are used on campuses, so more types were added later in round 2 as choices: these were: package unit, split AC, window AC and VRF.

	Chilled water (Air cooled)	Chilled water (water cooled)	Other (Please Specify)	Responses
All Data	3 (50%)	5 (83%)	0 (0%)	6

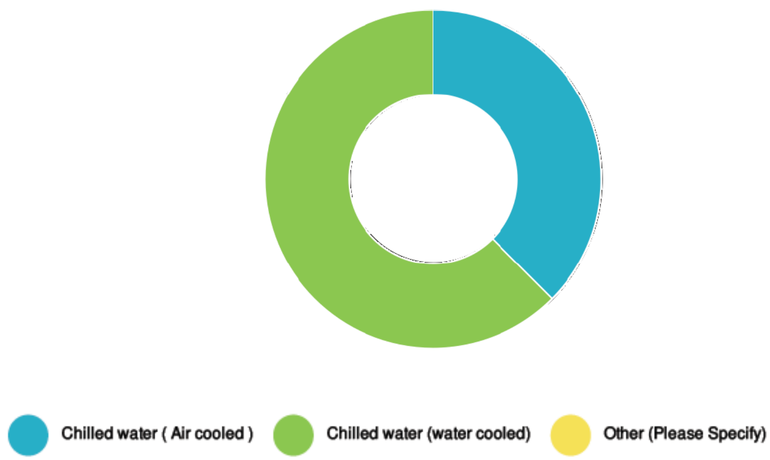

Figure 20.The Type of HVAC system used at the campus

Collected data for benchmarking

In this research, various sources were used to collect the data required for a study of the energy consumption performance of several educational campuses in Qatar. As a group, the gathered data could be the first step in populating a new database consisting of the names of campuses and their energy consumption across recent years (2010–2016). This database is a good platform to record energy performance data, facilitate benchmarking and exchange experiences to find best practices.

Figuring out the international energy ranks of educational campuses/buildings in Qatar is significant in determining where those buildings fall on the energy map and where they are going, keeping in mind several financial, environmental and social challenges presented in previous chapters. The data collected in this investigation is shown in Table 16.

The intention of this study was to benchmark several educational campuses/buildings in Qatar. These were QU, QF and AA; however, more data was available at hand for QU, so it was easier and more comprehensive to choose more buildings from QU for the analysis. Table 16 illustrates the availability of data for this analysis.

In this study, multiple ways of benchmarking were suggested:

1. First benchmark: each building campus was compared to a national database such as ENERGY STAR's Target Finder.

2. Second benchmark: each campus building was compared to similar buildings off campus.

3. Third benchmark each campus building was benchmarked against its different years of performance and consumption, with the single building using previous years as a baseline for benchmarking.

Table 16.Availability of data for benchmarking

Availability of data			
	Campus X	Campus Y	Campus Z
Building type and name			
Drawing plans			
Occupancy and number of occupants			
Areas of buildings			
Building function			
Year of construction and commencement of operations			
Utility readings and records			
Energy report			
Type of HVAC system			
Any green accreditation (GSAS, LEED)			

Legend

Available/enough	**Available, not complete**	**Not available**

Campus compared to a national database

For the first benchmark, each campus was compared to a national database such as ENERGY STAR's Target Finder; it was done by comparing EUI values of selected buildings with the EUI standard. The Commercial Buildings Energy Consumption Survey (CBECS) offers a benchmarking reference of EUI as a baseline of energy performance for each building type. For universities, each college takes the amount of 130.7 Btu/ft^2/year= 383 kWh/m^2/year. This value is provided by the ENERGY STAR database shown in Figure 21, published in 2014, which is considered to be the latest version.

U.S. National Median Reference Values for All Portfolio Manager Property Types

Broad Category	Primary Function	Further Breakdown (where needed)	Source EUI (kBtu/ft^2)	Site EUI (kBtu/ft^2)	Reference Data Source - Peer Group Comparison
Banking/Financial Services	Bank Branch *		252.8	87.0	CBECS - Bank/Financial
	Financial Office*		148.1	67.3	CBECS - Office & Bank/Financial
Education	Adult Education		141.4	59.6	CBECS - Education
	College/University		262.6	130.7	CBECS - College/University
	K-12 School*		141.4	58.2	CBECS - Elementary/Middle & High School
	Pre-school/Daycare		145.7	70.9	CBECS - Preschool
	Vocational School		141.4	59.6	CBECS - Education
	Other - Education				

Figure 21.Standard EUI values. Source: energy star 2014

Occupancy observation using a behavioral map

As mentioned in the previous chapter the data for number of occupants was not available in FM departments, the researcher planned to estimate this number by implementing an occupancy observation behavioral map. The floor plans in figures 22, 23 and 24 illustrate a behavioral map for women foundation building. The researcher did the observation for each building alone choosing three different times during the day. The process take place in different days to be able to cover all the buildings, table 17 is showing the detailed information for this observation. Doing 3 different observations a day was very important, in order to find the difference in occupants' distribution during the day. University fact sheets were also gathered to determine the number of students in each college; this assisted in evaluating the number of occupants. The researcher had chosen the month of November since activities on the campus are in maximum, most students are attending and no exams in place. Table 17 shows the final number of occupants at QU. Figure 25 illustrates a line chart for the occupation pattern during operation time.

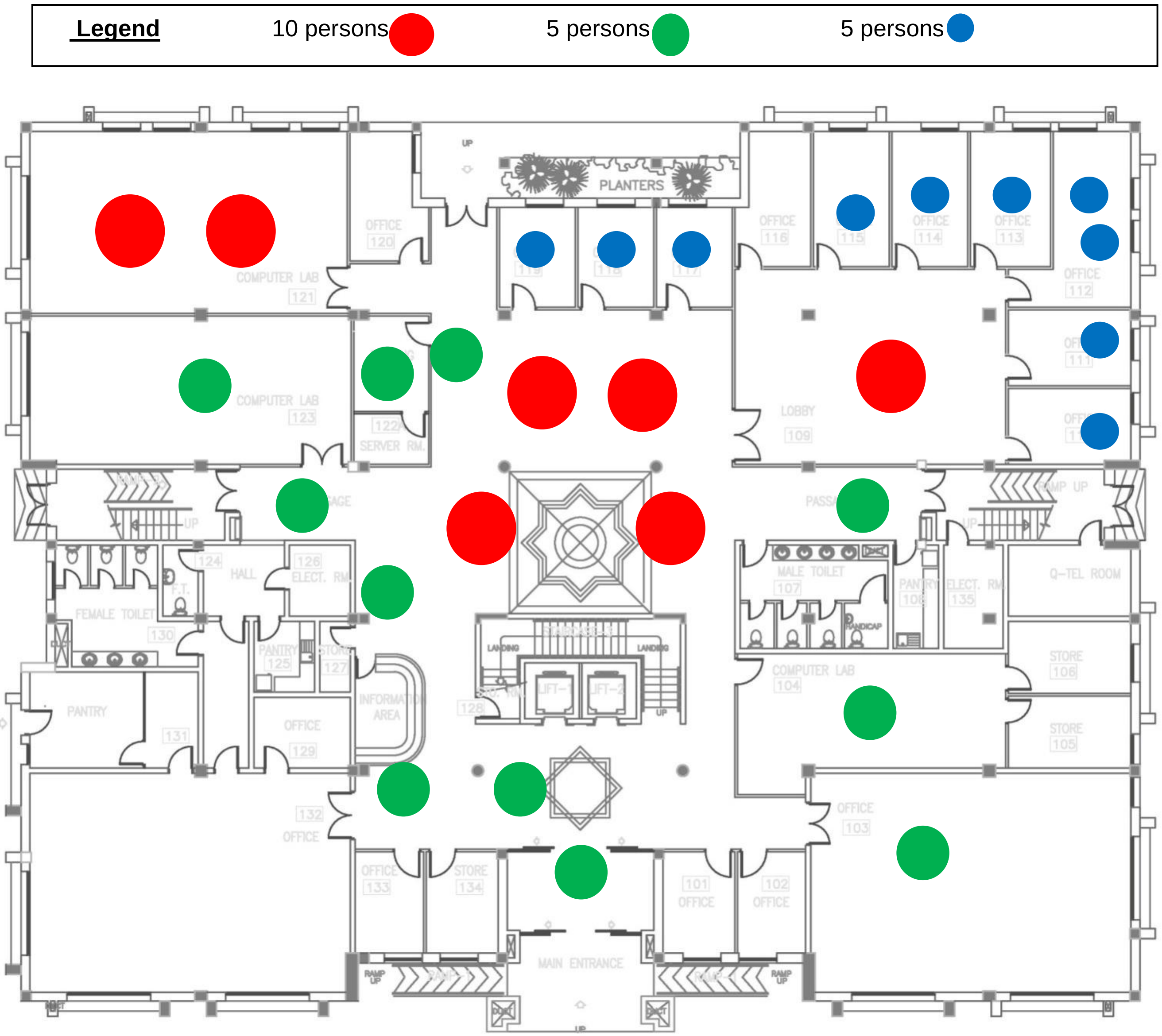

Figure 22.Women’s foundation – Ground floor - 2:00-2:15pm

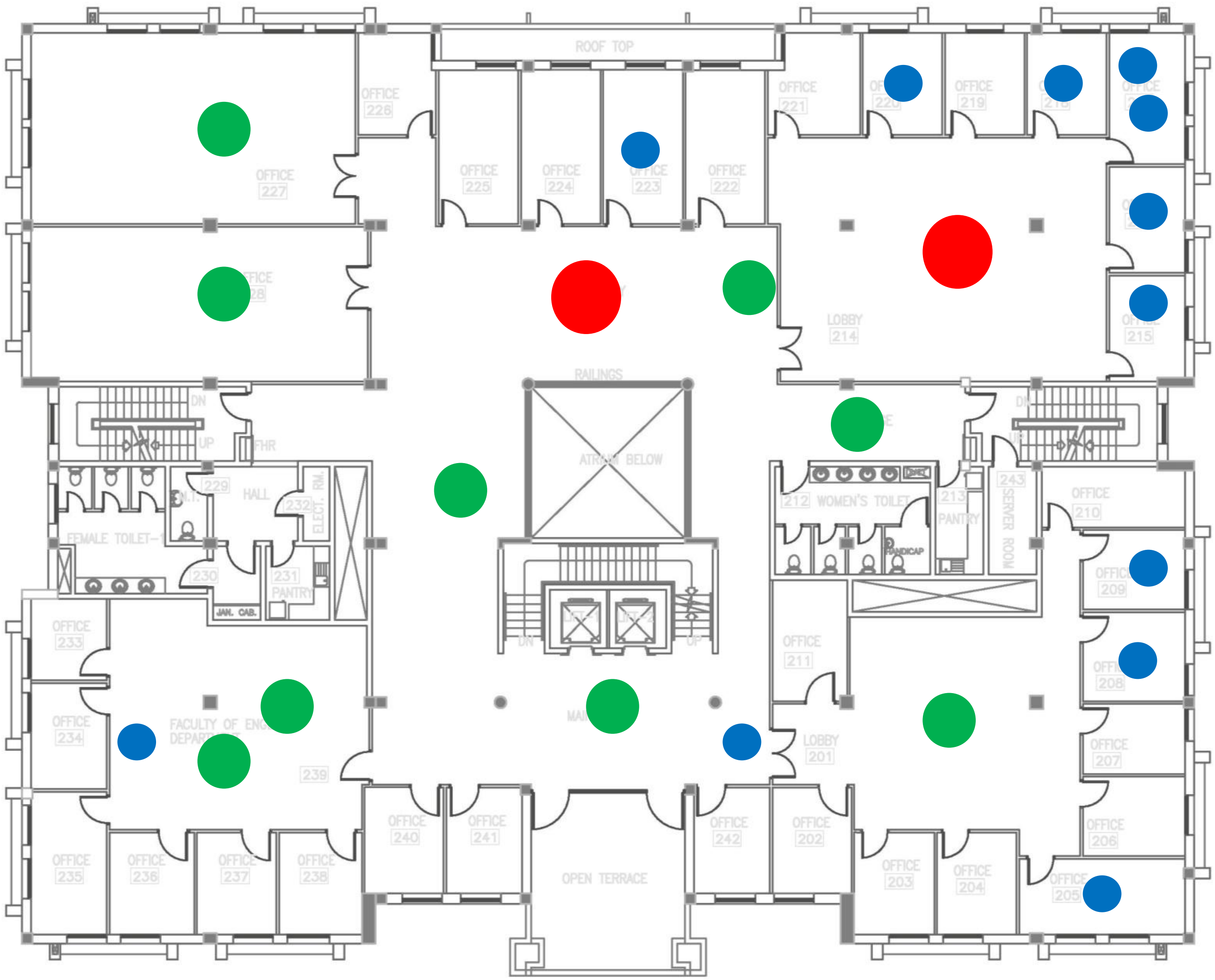

Figure 23.Women's foundation – First floor- 2:00-2:15pm

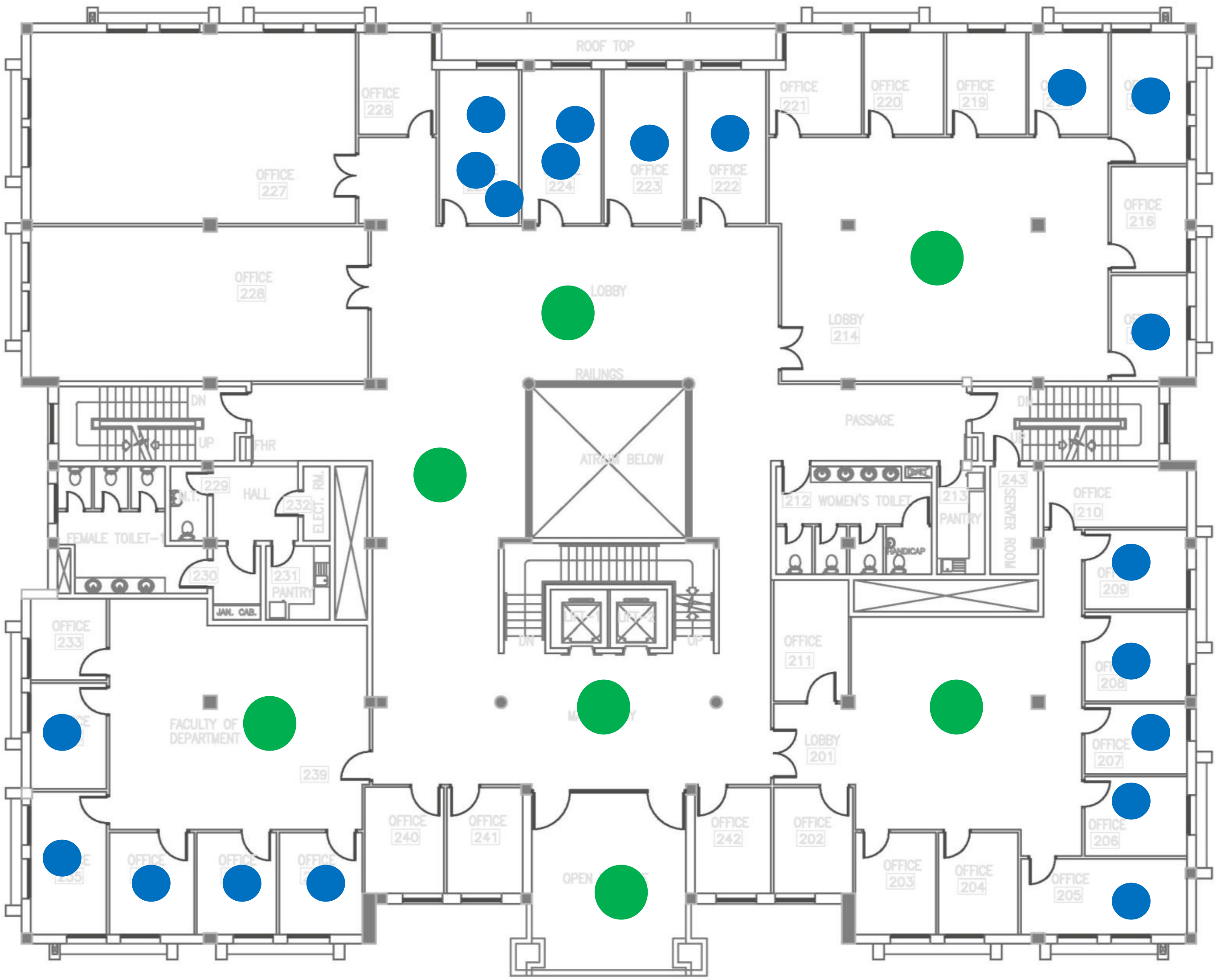

Figure 24.Women’s foundation – Second floor- 2:00-2:15 pm

Table 17.Number of occupants at QU buildings

	Case study 1	**Case study 2**	**Case study 3**	**Case study 4**	**Case study 5**	**Case study 6**	**Time of recording**
Date of recording	2^{nd} Nov2015	1^{st} Nov-2015	5^{th} Nov 2015	3^{rd} Nov - 2015	4^{th} Nov2015	8^{th} Nov -2015	
Building	Sharia college	women engineering college	Women’s foundation	Men’s foundation	Admission and registration	library	
Number of occupant	500	650	900	50	200	1500	10:00 AM- 10: 30 AM
	530	660	800	170	240	2000	12:00 PM- 12:30PM
	315	380	280	50	240	550	2:00PM- 2:30PM

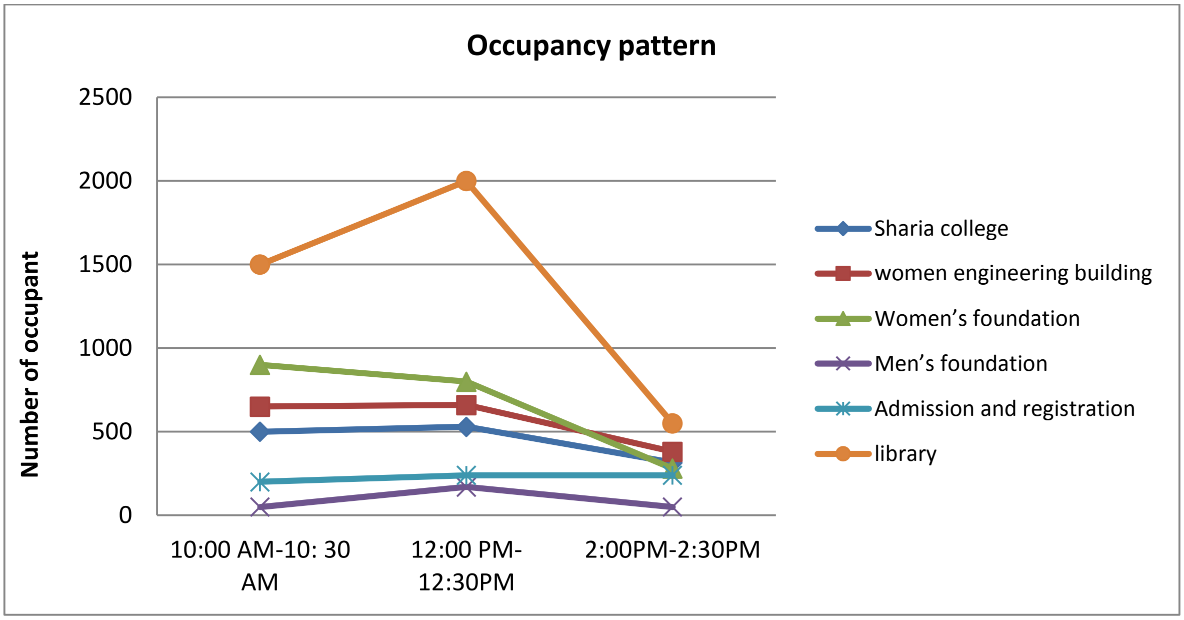

Figure 25. Occupancy pattern according to operation time

Chapter 5 :Analysis and results

Energy use analysis (electricity analysis)

Energy data was collected for three groups of campuses, as mentioned earlier in the methodology and procedure chapters. Those campuses were QU, QF and Aspire. The data acquired for the first campus, QU covered a period of four years (2011 to 2015), while the data acquired for the other two campuses, QF and Aspire was for one year only, 2014 to 2015. The data was collected for certain buildings and these were taken as case studies.

After the energy consumption data and other required data were collected, they were analyzed through several diagrams, charts and calculations to come up with the following findings:

1. The electricity consumption profile was determined by drawing the area graph for each building according to consumption throughout the year based on monthly readings.

2. Electricity base load is the minimum load for a building to operate.

3. Total consumption per year was found by adding up the consumption for 12 months of the year. This consumption was determined by subtracting the electricity readings for the intended month from the preceding month, as shown in Table 18. For instance, the reading of February was subtracted from the reading of January to find the consumption for February, as shown using this formula: 2,877,260 −

2,770,640 = 106,620. This was applied to the readings for all buildings, but the tables presented in this chapter display consumption only. Appendix D represents a sample of the electricity reading records.

Table 18 Consumption found from reading

Month of reading	1-Jan-12	1-Feb-12	1-Mar-12	1-Apr-12
Reading –kwh	2,770,640	2,877,260	2,965,910	3,082,160
Consumption - kwh	106,560	106,620	88,650	116,250

Energy use intensity (EUI) was calculated by dividing the total electricity consumption for one year by the total built area of the building. Table 19 displays the EUI standard for benchmarking.

Table 19.EUI standard for benchmarking. Source: Energy star 2014

Energy star standard for EUI kwh/m^2				
	Class room			Housing
Building Type	College building	Office building	Library	Dormitory
EUI value	383 kwh/m^2	197 kwh/m^2	268 kwh/m^2	216 kwh/m^2

4. Consumption per occupant was calculated by dividing the total electricity consumption for one year by the total number of occupants for a building.

5. Maximum load and minimum load were found by analyzing the details recorded and collected in monthly data sheets.

The analyzed data for each building was benchmarked through several approaches:

1. Comparing energy consumption for a particular building throughout different years of its operation.

2. Comparing a particular building's EUI throughout different years of its operation

3. Comparing the EUI of different campuses in Qatar

4. Benchmarking the EUI of Qatari campuses against the EUI standards of ENERGY STAR and (CBECS).

It was essential to study different building types on different campuses to differentiate the energy use patterns in those buildings. Those types have been classified under the following categories in Table 20.

Table 20.Building types for the case studies

• College buildings (class room buildings)	• Office building
• Dormitory	• Mix use buildings
• Library	

The following pages will describe the energy analyses for the case study buildings. This analysis will also discuss earlier points.

Qatar University will be labeled as QU with building names, while other buildings in other campuses will be named in code. Table 21 lists the case study buildings.

Table 21.Case study buildings

QU-Qatar University	Campus X	Campus Y
QU- Women sharia college	W - College Building	A -College Building
QU- Women foundation	U College Building	
QU-Men foundation building	Male housing	
QU- Administration and Registration building	Female housing	
QU- Women Engineering		
QU-Library		

Electricity consumption analysis

Case study 1 :QU Women's Sharia College building

The building contained classrooms for Sharia - Islamic Studies College and Business College as well before 2011. After 2011 to 2012, the Business College moved to another new building. Although the Business College students left in the middle of the academic year, the number of occupants in this building continued to increase. The Sharia program had an advantage of more space left by the business students, which led to an increase in the number of enrolled Sharia students. This affected energy consumption by increasing it, as illustrated in Table 22. Although electricity consumption was reduced through those years, it was considered to fluctuate in general. The number of occupants by year and floor area is shown in Table 22.

1. **Total consumption per year for electricity:** The total electricity consumption per year is shown in Table 22.

Table 22.Electricity consumption for women Sharia college building and other building data

Year	Total electricity consumption kwh	Area m^2	EUI kwh/m^2	Occupant	Co/Oc/year Kwh/Oc/year	Operating hours
2011	1,535,540		388.35	300	5,118.47	
2012	1,499,750		379.30	470	3,190.96	Full operation 6:00AM-
2013	1,504,510	**3954**	380.50	490	3,070.43	10:00PM
2014	1,480,460		374.42	510	2,902.86	During vacations
2015	1,504,670		380.54	530	2,839.00	7:00AM-4:00

2. **Electricity consumption profile:** The consumption profile by month of the year is shown in the graph area of Figure 26. Moreover, detailed consumption is shown in Table 23. Months with the lowest consumption in the year are colored green and months with the highest consumption are colored yellow.

   The electricity consumption profile shows approximate base load consumption in the winter months. The graph area starts with low consumption in winter and grows to reach increasingly high levels in September and October as the academic year starts with all of its activities. Additionally, the whole number of occupants is almost complete at the beginning of the academic year. The consumption in peak summer seasons (June, July, and August) is high but fluctuates according to the occupancy rate and summer schedules because the building is not fully operational in summer which changes year to year.

   In January, exams take place, and the number of students reaches maximum levels during this period; this explains the rise in energy consumption for January among other winter months. At the end of January and the first two weeks of February, the operation of the building is cut to 65 percent as the mid academic year vacation takes place.

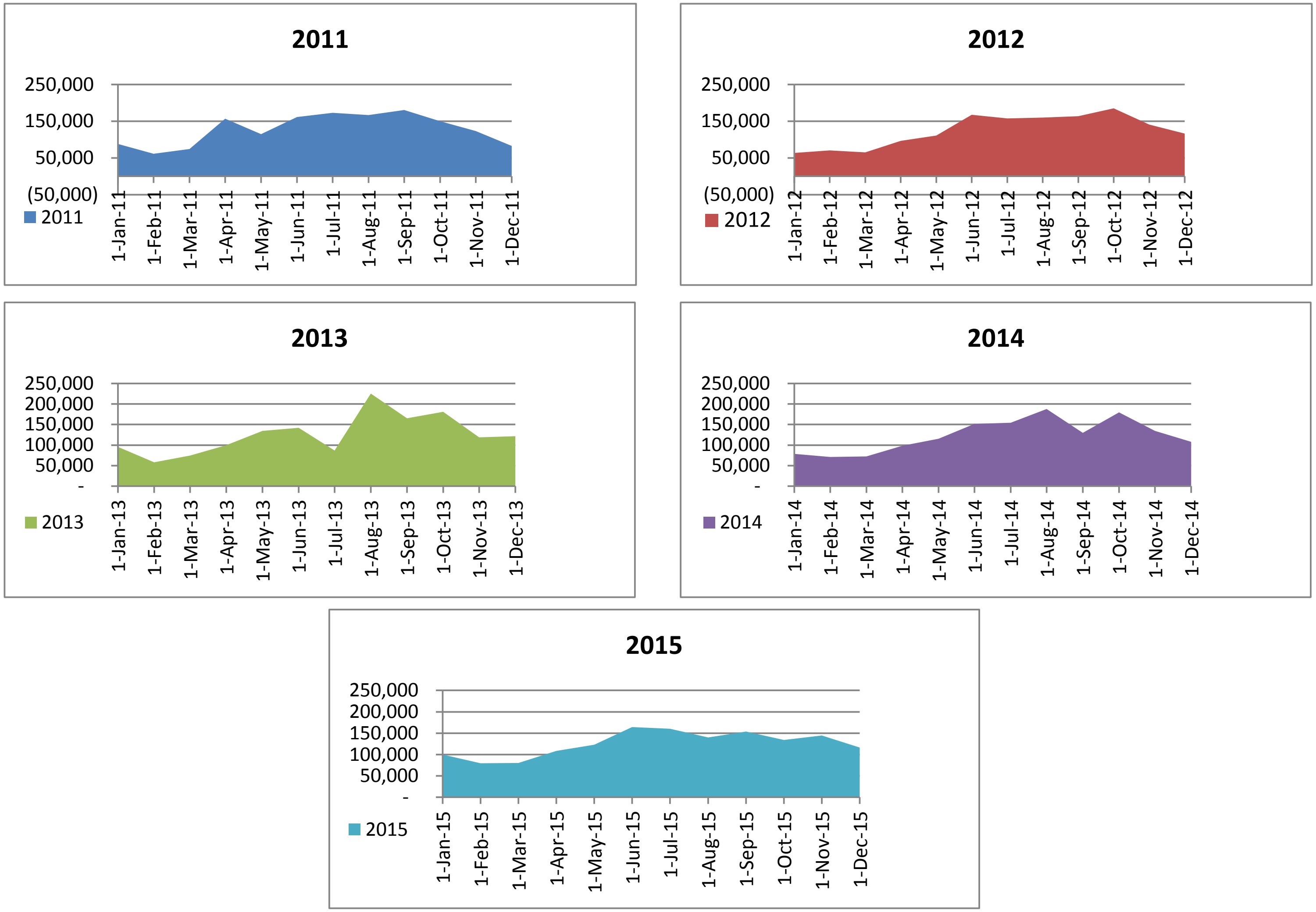

Figure 26: Electricity consumption profile from 2011 to 2015 for Sharia College building kwh/month

Table 23.Monthlyelectricity consumption for Women Sharia College 2011-2015 kwh/month

Min	
Max	

QU- WOMEN Sharia											
2011											
1-Jan	**1-Feb**	**1-Mar**	**1-Apr**	**1-May**	**1-Jun**	**1-Jul-**	**1-Aug**	**1-Sep-**	**1-Oct**	**1-Nov**	**1-Dec**
88,130	61,170	74,650	157,220	114,980	161,890	173,380	166,930	180,820	150,180	123,220	82,970
2012											
1-Jan	**1-Feb**	**1-Mar**	**1-Apr**	**1-May**	**1-Jun**	**1-Jul-**	**1-Aug**	**1-Sep-**	**1-Oct**	**1-Nov**	**1-Dec**
63,670	70,180	65,490	96,600	111,350	167,960	158,070	160,370	163,690	185,090	141,040	116,240
2013											
1-Jan	**1-Feb**	**1-Mar**	**1-Apr**	**1-May**	**1-Jun**	**1-Jul-**	**1-Aug**	**1-Sep-**	**1-Oct**	**1-Nov**	**1-Dec**
95,910	58,250	74,460	99,470	134,800	142,070	87,090	225,240	165,140	181,030	119,150	121,900
2014											
1-Jan	**1-Feb**	**1-Mar**	**1-Apr**	**1-May**	**1-Jun**	**1-Jul-**	**1-Aug**	**1-Sep-**	**1-Oct**	**1-Nov**	**1-Dec**
78,510	70,800	72,570	98,450	115,210	151,690	154,360	187,490	129,540	179,450	134,510	107,880
2015											
1-Jan	**1-Feb**	**1-Mar**	**1-Apr**	**1-May**	**1-Jun**	**1-Jul-**	**1-Aug**	**1-Sep-**	**1-Oct**	**1-Nov**	**1-Dec**
99,940	79,710	80,100	108,520	123,070	164,170	160,440	140,220	153,830	134,020	144,500	116,150

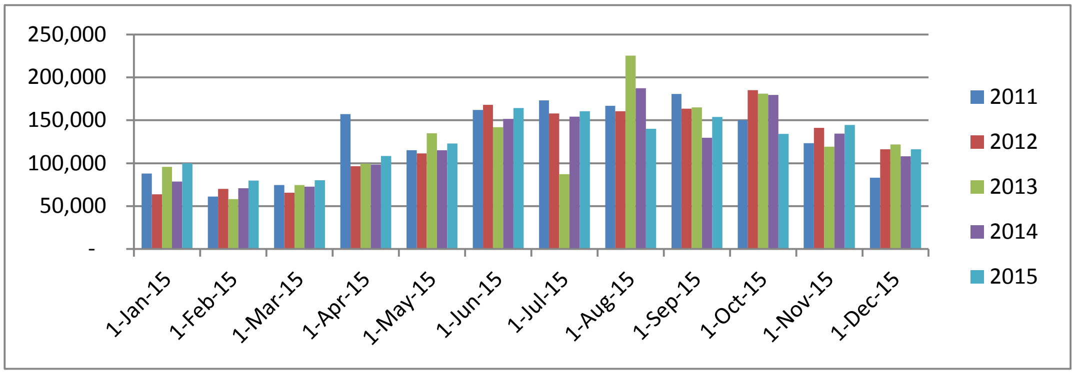

Figure 27: Electricity consumption for women Sharia College from 2011 to 2015

3. **Electricity base load:** This appears to be not less than 61,170 kWh/month.

4. **EUI:** The EUI value was high and above the benchmark in 2011, but after 2011 it started to decrease, as shown in the graph figure 28. After 2014, the EUI value increases; although EUI values are increasing, they are still under the standard and satisfying the benchmark, intended here to be less than 383 kWh/m^2. Conversely, considering future plans, conservation practices must be taken into consideration as the EUI is likely to increase with an increase in students.

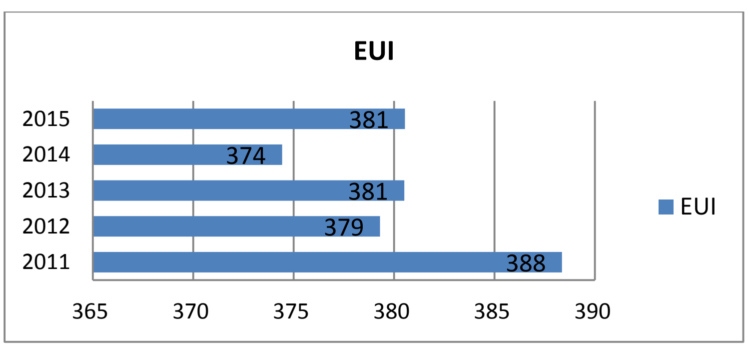

Figure 28.EUI values for Women Sharia college from 2011 to 2015

5. **Consumption per occupant:** Consumption per occupant shows a decrease as the number of occupants increases. The consumption is almost constant, increasing a little throughout the studied years. However, the number of occupants increases by quite a large rate. This results in a reduction in the consumption per occupant values, as shown in the bar chart of Figure 29. Figure 30 shows the consumption in regard to the number of occupants which is increasing from 300-500 occupants.

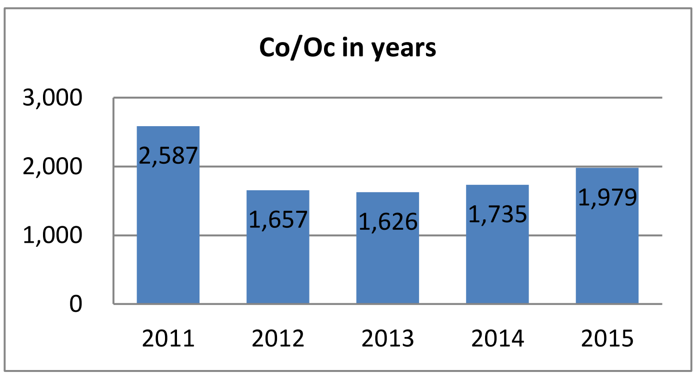

Figure 29.Consumption per occupant in years (2011-2015) kwh/occupant/year

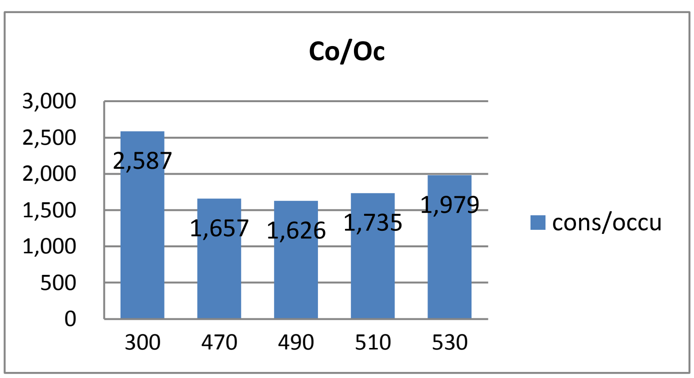

Figure 30.Consumption per occupant according to the numberof occupants

6. **Maximum load and minimum load according to monthly records:** The minimum and maximum consumption loads for this building were very near to those of other classroom buildings. They were 61,170 kWh/month and 225,240 kWh/month, respectively. The minimum consumption is figured out during the winter season, while the maximum is figured out during the summer - this is because of the AC load during summer. The findings reflect the amount of energy consumed by the AC.

To present more accurate figures for maximum and minimum values and to avoid outlier data as well as exceptional points that might happen once, the average for all minimum and maximum values is calculated in table 24.

Table 24.The average for all minimum and maximum consumption values

	Min	**Max**
2011	61,170	180,820
2012	63,670	185,090
2013	58,250	225,240
2014	70,800	187,490
2015	79,710	164,170
Average	66,720	188,562

Case study 2: QU Women's Engineering College building

The building contains classrooms for the Women's Engineering College. The number of occupants by year and floor area is shown in Table 25.

1. **Total consumption per year for electricity:** The total electricity consumption per year is shown in Table 25.

Table 25.Electricity consumption for women engineering college building and other building data

Year	Total electricity consumption kwh	Area m2	EUI kwh/m2	occupant	Co/Oc/year kwh/oc/year	Operating hours
2011	1,164,340		91.80	450.00	2,587.42	
2012	1,160,060		91.46	700.00	1,657.23	Full operation 6:00AM-10:00
2013	1,057,030	**12684**	83.34	650.00	1,626.20	
2014	1,127,710		88.91	650.00	1,734.94	During vacations 7:00AM-5:00
2015	1,306,450		103.00	660.00	1,979.47	

2. **Electricity consumption profile:** The consumption profile by month of the year is shown in the graph area of Figure 31. Moreover, detailed monthly consumption is shown in Table 26. Months with the lowest consumption in the year are colored green and months with the highest consumption are colored yellow. As for the previous building, the electricity consumption profile shows low consumption in the winter months and increasingly high levels as the academic year starts.

Consumption is high in peak summer seasons but fluctuates according to occupancy rates and summer schedules. The January exams explain the rise in energy consumption during this month, and tell us that the operation of the building is cut to 65 percent during the winter vacation when the college building operates for only 9 to 10 hours instead of 15 to 16 hours per day.

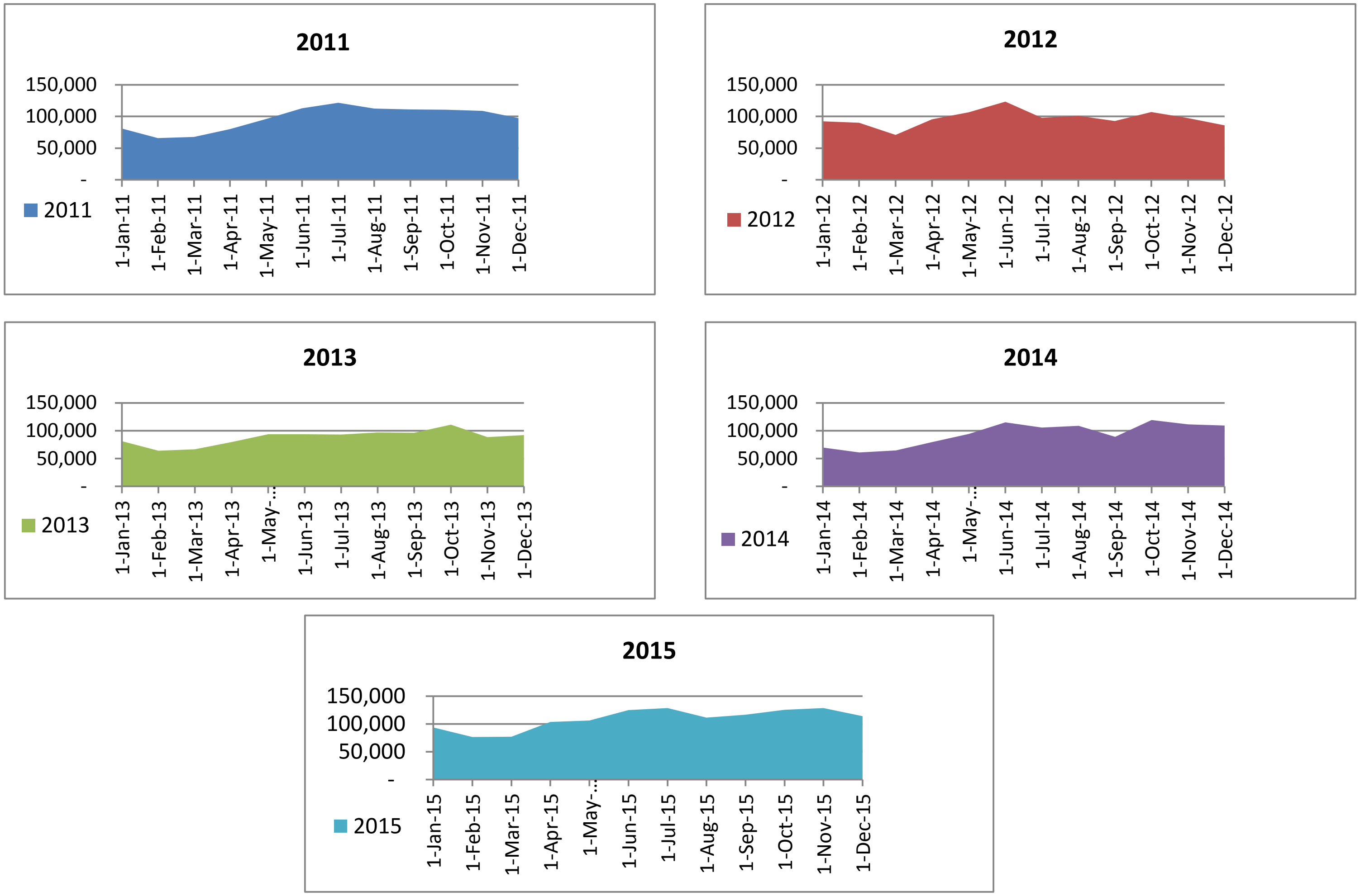

Figure 31: Electricity consumption profile from 2011 to 2015 kwh/month

Table 26.Monthly electricity consumption for women engineering college 2011-2015 kwh/month

Min	
Max	

QU- WOMEN Engineering											
2011											
1-Jan	**1-Feb**	**1-Mar**	**1-Apr**	**1-May**	**1-Jun**	**1-Jul-**	**1-Aug**	**1-Sep-**	**1-Oct**	**1-Nov**	**1-Dec**
80,820	65,800	67,710	79,770	96,000	112,980	121,400	112,180	111,110	110,710	108,740	97,120
2012											
1-Jan	**1-Feb**	**1-Mar**	**1-Apr**	**1-May**	**1-Jun**	**1-Jul-**	**1-Aug**	**1-Sep-**	**1-Oct**	**1-Nov**	**1-Dec**
92,500	89,970	70,720	95,620	106,320	123,410	97,560	100,910	92,780	106,970	97,170	86,130
2013											
1-Jan	**1-Feb**	**1-Mar**	**1-Apr**	**1-May**	**1-Jun**	**1-Jul-**	**1-Aug**	**1-Sep-**	**1-Oct**	**1-Nov**	**1-Dec**
81,070	64,100	66,740	79,540	93,830	93,500	93,040	97,020	96,520	111,000	88,440	92,230
2014											
1-Jan	**1-Feb**	**1-Mar**	**1-Apr**	**1-May**	**1-Jun**	**1-Jul-**	**1-Aug**	**1-Sep-**	**1-Oct**	**1-Nov**	**1-Dec**
69,600	61,030	64,800	79,410	94,010	115,040	105,720	108,940	88,950	119,410	111,300	109,500
2015											
1-Jan	**1-Feb**	**1-Mar**	**1-Apr**	**1-May**	**1-Jun**	**1-Jul-**	**1-Aug**	**1-Sep-**	**1-Oct**	**1-Nov**	**1-Dec**
93,630	76,570	76,750	103,730	106,300	124,730	128,770	111,370	116,360	125,260	128,810	114,170

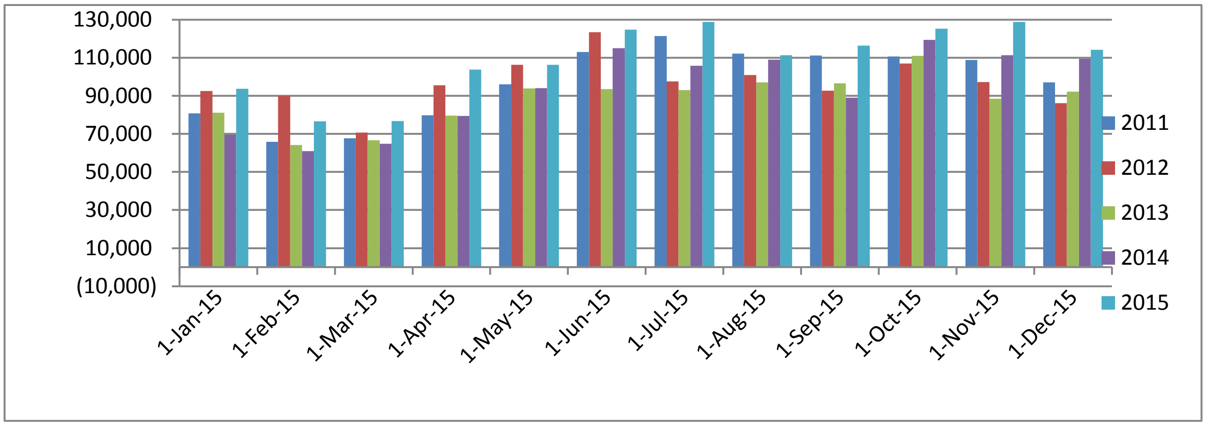

Figure 32.Electricity consumption for women engineering college from 2011 to 2015 kwh/month

3. **Electricity base load:** This appears to be not less than 61,030 kWh/month.

4. **EUI:** The women's engineering building showed great levels of EUI and consumption per occupant as well, this is much better than other broad buildings launched as benchmarks bar graph in figure 33 illustrates this. This is for two reasons:

- The type of ACMV system, which is a district cooling chiller.
- The adequate proportion between the number of occupants and the total electricity consumption.

This result presents this building as an ideal one among others in terms of electricity conservation.

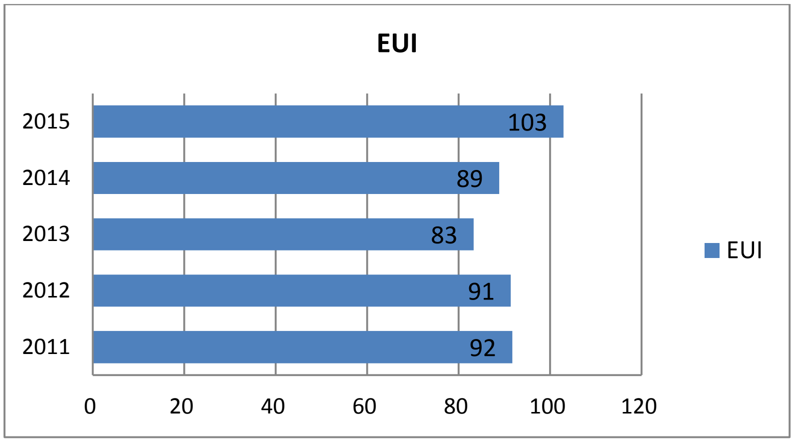

Figure 33.EUI values for women engineeringcollege from 2011 to 2015

5. **Consumption per occupant:** As consumption is almost constant (increasing a little) but the number of occupants is also increasing, this results in a reduction in consumption per occupant values, as shown in the charts of Figures 34 and 35.

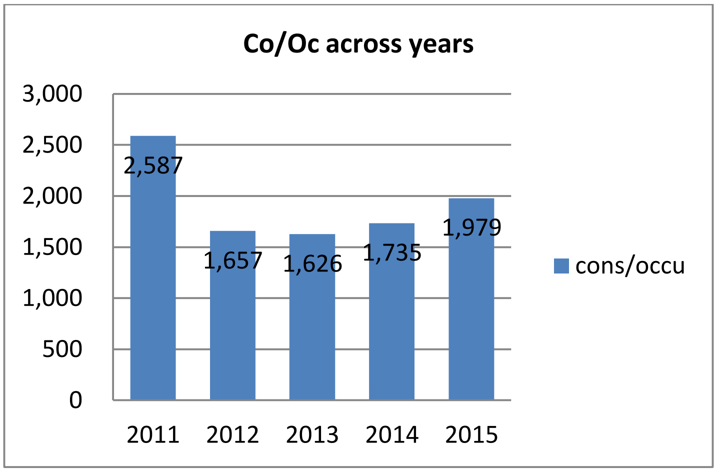

Figure 34.consumption per occupant in years (2011-2015) kwh/occupant/ year

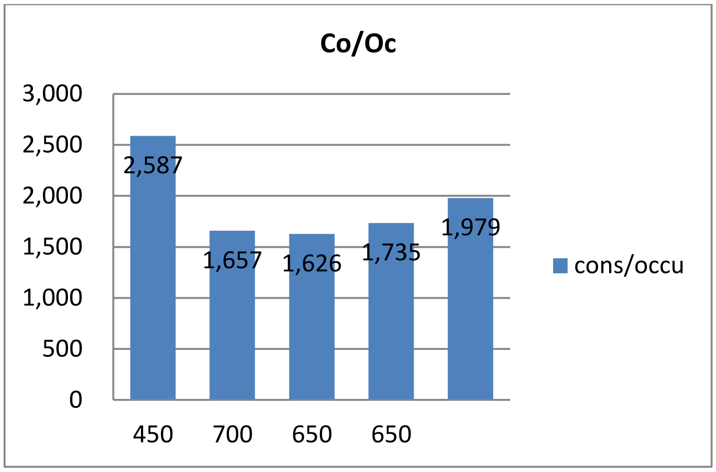

Figure 35.consumption per occupant according to the number of occupants

6. **Maximum load and minimum load according to monthly records:** The minimum and maximum consumption loads for this building are 61,030 kWh per month and 128,810 kWh per month, respectively. Although the floor area for this building is double or triple that of other buildings in this study, its electricity consumption is close to theirs and this is mainly because of the type of HVAC used.

Case study 3: QU Women's Foundation building

The building contains classrooms for the Women's Foundation program. After the cancelation of the foundation program, it has taken the function of both an office building and classroom building, as well. On top of that, this building is used by students waiting for their cars, so it has another function of a waiting station. The number of occupants by year and floor area is shown in Table 27.

1. **Total consumption per year for electricity:** The total electricity consumption per year is shown in Table 27, while the water consumption cannot be detected for this building alone, since it has no separate water meter. As mentioned earlier in this research, QU has one water meter for the whole campus.

Table 27.Electricity consumption for women foundation building and other building data

Year	Total electricity consumption kwh	Area m2	EUI kwh/m2	Occupant	Co/Oc/year	Operating hours
2011	1,753,520		390.45	880.00	1,992.64	
2012	1,695,030		377.43	1,200.00	1,412.53	Full operation
2013	1,678,570	4491	373.76	1,200.00	1,398.81	6:00AM-9:00
2014	1,841,730		410.09	1,300.00	1,416.72	During vacations
2015	2,054,590		457.49	1,400.00	1,467.56	7:00AM-4:00

2. **Electricity consumption profile:** The consumption profile by months of the year is shown in the area graph of Figure 37. Moreover, electricity monthly

consumption is shown in Table 28. The month with the lowest consumption is colored green and the month with the highest consumption is colored yellow.

As for the previous building, the electricity consumption profile shows low consumption in winter months and increasingly high levels as the academic year starts. Consumption is high in peak summer seasons but fluctuates according to occupancy rates and summer schedules, exams take place in January and this explain the rise in energy consumption during this month, and it shows that the operation of the building is cut to 65 percent during the winter vacation.

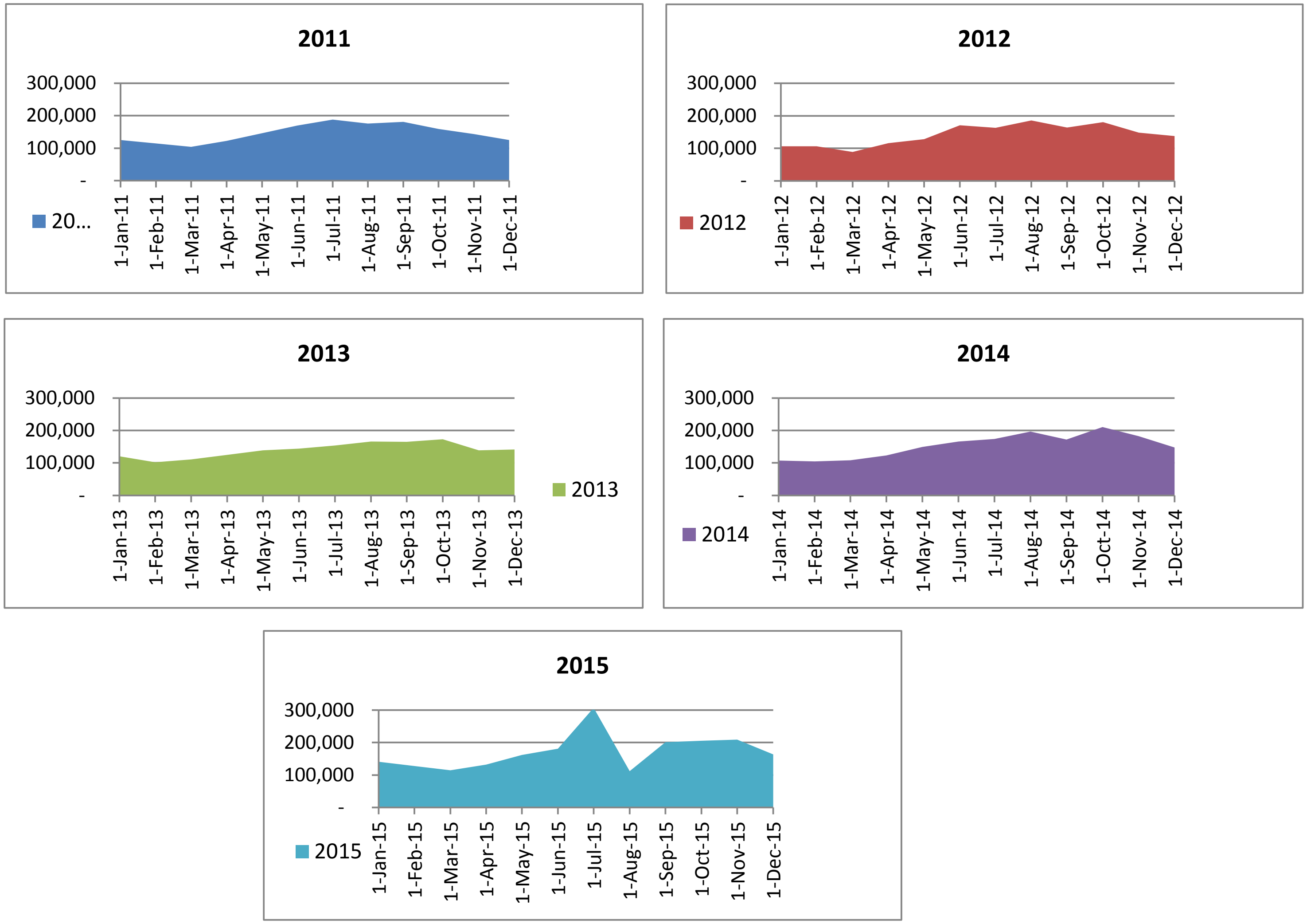

Figure 37.Electricity consumption profile for women foundation building from (2011 to 2015) kwh/month

Min	
Max	

Table 28.Monthly electricity consumption for women'sfoundation building 2011-2015 kwh/month

QU- WOMEN'S FOUNDATION BUILDING											
2011											
1-Jan	**1-Feb**	**1-Mar**	**1-Apr**	**1-May**	**1-Jun**	**1-Jul-**	**1-Aug**	**1-Sep-**	**1-Oct**	**1-Nov**	**1-Dec**
125,230	114,510	103,720	122,150	145,660	169,560	188,080	176,130	180,700	159,320	143,570	124,890
2012											
1-Jan	**1-Feb**	**1-Mar**	**1-Apr**	**1-May**	**1-Jun**	**1-Jul-**	**1-Aug**	**1-Sep-**	**1-Oct**	**1-Nov**	**1-Dec**
106,560	106,620	88,650	116,250	127,700	170,810	163,000	185,630	163,540	180,180	148,030	138,060
2013											
1-Jan	**1-Feb**	**1-Mar**	**1-Apr**	**1-May**	**1-Jun**	**1-Jul-**	**1-Aug**	**1-Sep-**	**1-Oct**	**1-Nov**	**1-Dec**
120,430	102,420	110,500	124,570	139,020	144,440	154,010	166,180	164,660	172,470	138,740	141,130
2014											
1-Jan	**1-Feb**	**1-Mar**	**1-Apr**	**1-May**	**1-Jun**	**1-Jul-**	**1-Aug**	**1-Sep-**	**1-Oct**	**1-Nov**	**1-Dec**
107,000	104,380	108,300	122,650	149,540	165,580	174,000	196,930	172,420	210,830	182,110	147,990
2015											
1-Jan	**1-Feb**	**1-Mar**	**1-Apr**	**1-May**	**1-Jun**	**1-Jul-**	**1-Aug**	**1-Sep-**	**1-Oct**	**1-Nov**	**1-Dec**
140,750	127,810	114,690	132,290	161,581	181,049	306,870	112,080	200,860	204,980	208,510	163,120

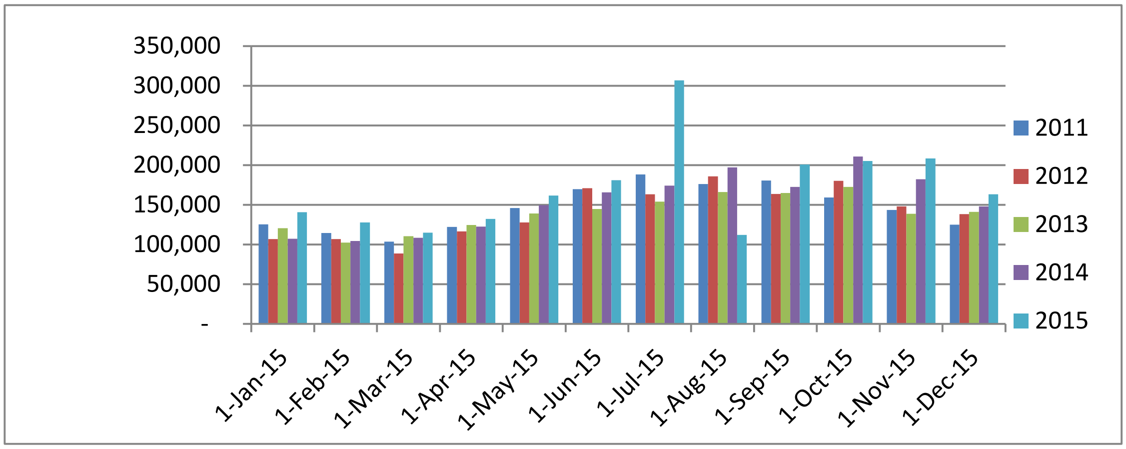

Figure 38.Electricity consumption for women's foundation building from (2011 to 2015) kwh/month

3. **Electricity base load:** This appears to be not less than 88,650 kWh/month, and it is high compared to other buildings at QU. This high amount of consumption is because of three main reasons:

    1. The type of the HVAC used (DX-Package unit)
    2. The high number of students
    3. The activities within the building, as it is used by students waiting for their cars and therefore functions as a waiting station.

4. **EUI:** In this building, scoring a high EUI as shown in figure39 did not prevent getting low consumption per occupant score. EUI was much above the standard, as the previous year's EUI was 457 kWh/m^2, while the standard is 383 kWh/m^2, so the difference is 74 degrees. On the other hand, consumption per occupant was

much less than the benchmark as the benchmark is 2,000 - 2,700 kWh per student per year, while the building record is less than 1500 kWh per student per year.

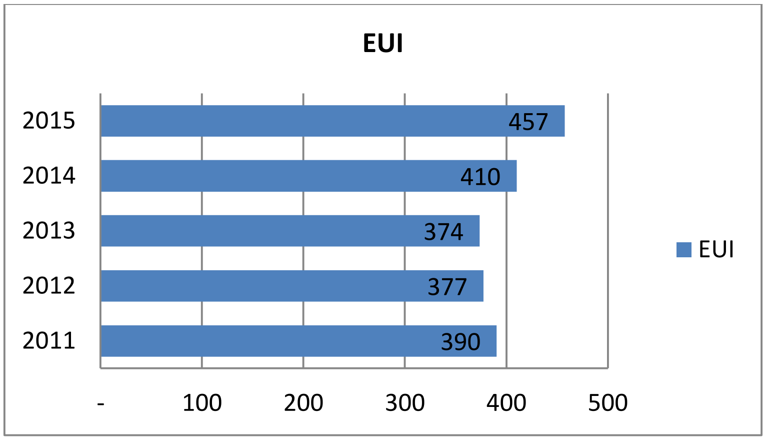

Figure 36.EUI values for women foundation building from 2011 to 2015

5. **Consumption per occupant:** Consumption per occupant shows a decrease, since the number of occupants has increased. These values are shown in the bar graphs of Figures 39 and 40 according to year and to the increase of occupants respectively.

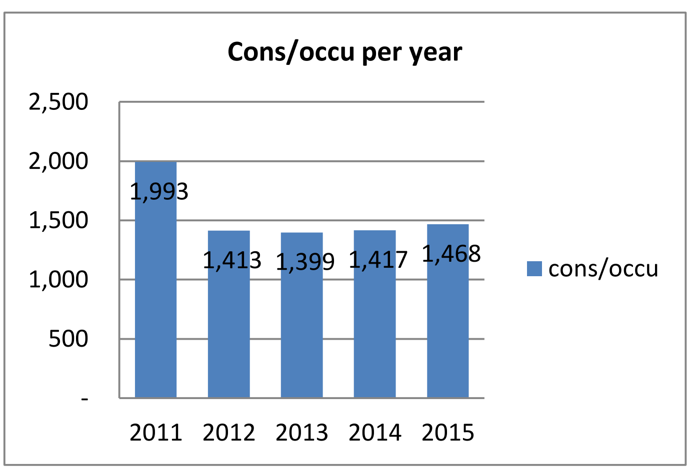

Figure 37.consumption per occupant in years (2011-2015) kwh/occupant/year

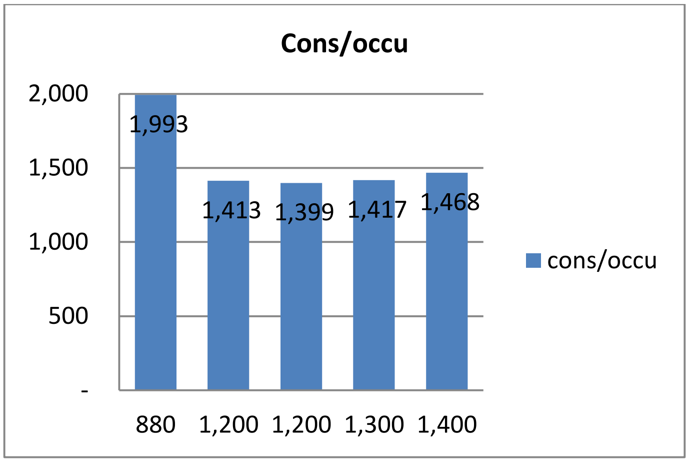

Figure 38.consumption per occupant according to the number of occupants

6. **Maximum load and minimum load according to monthly records:** The minimum and maximum consumption loads for this building were very near to those of other classroom buildings. They were 88,650 kWh/month and 306,870 kWh/month, respectively. These are high compared to other buildings at QU because of the three reasons listed previously.

   a. The type of the HVAC used (DX-Package unit)

   b. The high number of students

   c. The activities within the building, as it is used by students waiting for their cars and therefore functions as a waiting station.

Case study 4: QU Men's Foundation building

Studying the function of this building over different years was significant, as it affects the number of occupants and their activities. The parameters of occupant numbers and building function affected electricity consumption patterns throughout the investigated period, 2011 to 2015. The number of occupants by year and floor area is shown in Table 29.

The building contained classrooms for the foundation program before 2011. After 2011 to 2012, the program was partially canceled, and the number of students dropped in the succeeding years. As a result of this, most of the classrooms were turned into offices, and the building's function started to become administrative. However, some computer labs were kept in the building; the building is now considered to be a mix of both administrative offices and classrooms. This decreased energy consumption from 1,160,400 kWh in 2011 to 1,221,030 kWh and 1,042,230 kWh in 2012 and 2013, respectively. See Table 29 for an illustration. Although electricity consumption was reduced over those years, it is considered to fluctuate in general.

1. **Total consumption per year:** The total electricity consumption per year is shown in Table 29, while the water consumption cannot be detected for this building alone, since as previously stated, QU has one water meter for the whole campus.

Table 29.Electricity consumption for men 's foundation building and other building data

Year	Total kwh	Area m2	EUI kwh/m2	Occupant	Co/Oc/year	Operating hours
2011	1,160,400	3750	309.44	240.00	4,835.00	Full operation 6:00AM-9:00 During vacations 7:00AM-4:00
2012	1,221,030		325.61	220.00	5,550.14	
2013	1,042,230		277.93	220.00	4,737.41	
2014	1,142,570		304.69	200.00	5,712.85	
2015	1,211,680		323.11	170.00	7,127.53	

2. **Electricity consumption profile:** The consumption profile by month of the year is shown in the graph area of Figure 41, and detailed consumption is shown in Table 3. The month with the lowest consumption is colored green, and the month with the highest consumption is colored yellow.

   As for the previous building, the electricity consumption profile shows low consumption in the winter months and increasingly high levels as the academic year starts. Consumption is high in peak summer seasons but fluctuates according to occupancy rates and summer schedules. Although different years show almost the same consumption profile, consumption fluctuated in the years 2011 and 2012, when the building housed a complete foundation program and classrooms. After 2012 to 2015, when the building started to act as an administrative building, the fluctuation decreased and the graph almost settled down.

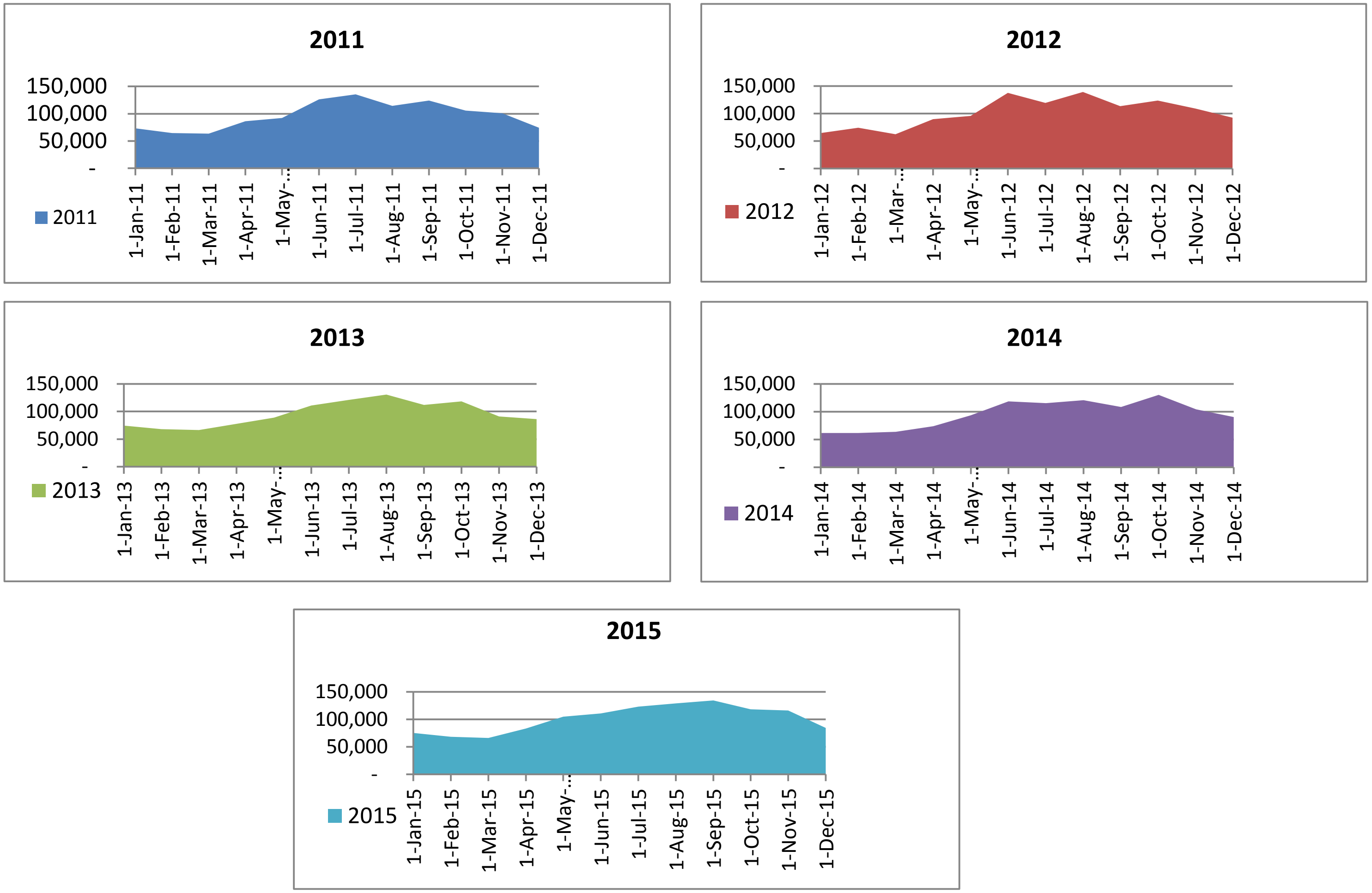

Figure 39: Electricity consumption profile for men 's foundation building from (2011 to 2015) kwh/month

Table 30.Monthly electricity consumption for men's foundation building (2011-2015) kwh/month

Min	(green)
Max	(orange)

QU- Men Foundation											
2011											
1-Jan	**1-Feb**	**1-Mar**	**1-Apr**	**1-May**	**1-Jun**	**1-Jul-**	**1-Aug**	**1-Sep-**	**1-Oct**	**1-Nov**	**1-Dec**
73,190	64,470	63,240	86,170	92,110	126,200	135,430	114,510	123,850	105,830	101,060	74,340
2012											
1-Jan	**1-Feb**	**1-Mar**	**1-Apr**	**1-May**	**1-Jun**	**1-Jul-**	**1-Aug**	**1-Sep-**	**1-Oct**	**1-Nov**	**1-Dec**
64,290	74,090	62,140	89,680	95,720	137,600	119,250	139,250	113,680	123,680	108,920	92,730
2013											
1-Jan	**1-Feb**	**1-Mar**	**1-Apr**	**1-May**	**1-Jun**	**1-Jul-**	**1-Aug**	**1-Sep-**	**1-Oct**	**1-Nov**	**1-Dec**
74,520	67,920	66,190	77,700	89,040	111,010	121,000	130,990	112,240	118,240	90,830	86,100
2014											
1-Jan	**1-Feb**	**1-Mar**	**1-Apr**	**1-May**	**1-Jun**	**1-Jul-**	**1-Aug**	**1-Sep-**	**1-Oct**	**1-Nov**	**1-Dec**
61,560	61,490	63,930	73,800	93,480	118,820	115,490	120,700	108,540	130,512	104,078	90,170
2015											
1-Jan	**1-Feb**	**1-Mar**	**1-Apr**	**1-May**	**1-Jun**	**1-Jul-**	**1-Aug**	**1-Sep-**	**1-Oct**	**1-Nov**	**1-Dec**
75,210	67,900	66,070	83,000	104,470	110,460	123,000	128,790	134,120	118,220	116,010	84,430

3. **Electricity base load:** This appears to be not less than 61,490 kWh/month.

4. **EUI:** The EUI for the Men's Foundation building was calculated for the period 2011 to 2015. This calculation resulted in excellent records, considering that the building housed classrooms but has actually been used for mixed purposes since 2011. It scored values less than the standard values of ENERGY STAR and CBECS for a building with classrooms. See Figure 43, which represents a bar chart of EUI among the studied years.

The building scored good EUI values when it was considered to be a building with classrooms, since its EUI was less than 383 kWh/m^2, but after becoming an office building, its EUI was considered to be very high since it was measured at above 300 kWh/m^2 when it should only be around 197. Refer to Table 19 for EUI standards.

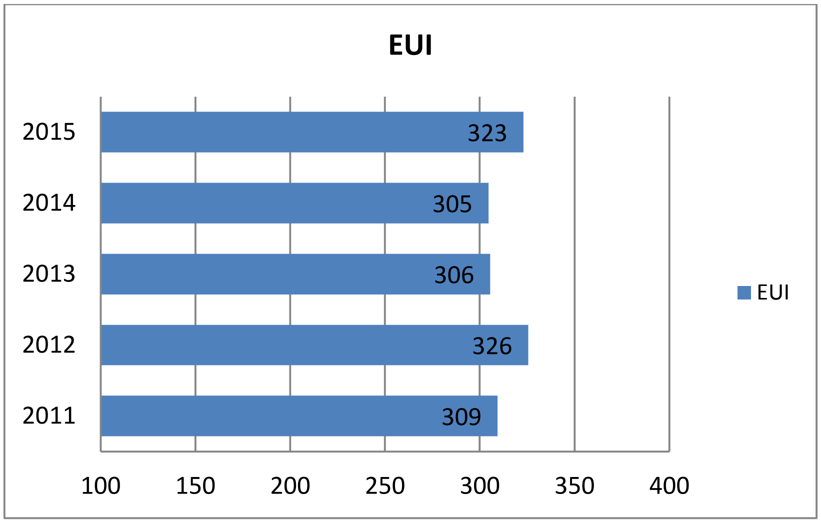

Figure 40.EUI values for men foundation building from 2011 to 2015

5. **Consumption per occupant:** Levels of consumption per occupant between 2011 and 2015 increased, as illustrated in the bar graph in Figure 45. Because the number of occupants decreased as the ratio of consumption per occupant increased, and this needs to be taken into consideration. Since the number of occupants decreased, the heat load inside the building also decreased. As a result, the consumption per occupant value needs to be less, not more.

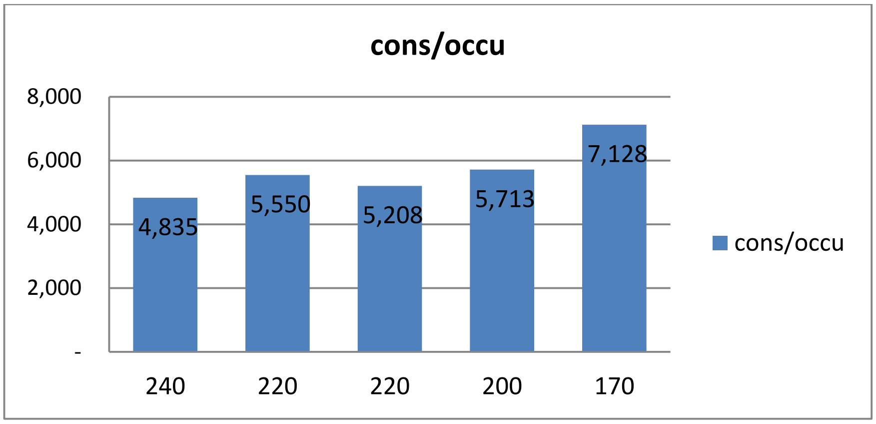

Figure 41.Consumption per occupant according to the number of occupants

6. **Maximum load and minimum load according to monthly records:** The minimum and maximum consumption loads for this building were close to those of other classroom buildings. They were 61,490 kWh/month and 139250 kWh/month, respectively. This raises an important query: Why is the building consuming almost the same amount in both different stages with totally different functions? Consumption should decrease proportionally with the decrease of the number of occupants; in this case, the FM is still dealing with the building as if it were a classroom building when it no longer serves that function.

Case study 5: QU admission and registration building

The admission and registration building is an office building providing admission and registration services for students. This investigation examines this building as an office building on an education campus. The operating hours for this building are less than those of buildings with classrooms, since working hours for employees are from 7:30 a.m. to 2:30 p.m. The number of occupants by year and floor area is shown in Table 31.

1. **Total consumption per year for electricity and water:** The total electricity consumption per year is shown in Table 31.

Table 31.Electricity consumption for addmission and registration building and other building data

Year	SUM	Area	EUI	occupant	Co/Oc/year	Operating hours
2011	1,010,810		297.73	170	5,945.94	Full operation 6:00AM-2:30PM
2012	1,148,350		338.25	200.00	5,741.75	
2013	1,157,030	**3395**	340.80	200.00	5,785.15	
2014	1,219,870		359.31	240.00	5,082.79	During vacations 6:00AM-2:30PM
2015	1,215,920		358.15	240.00	5,066.33	

2. **Electricity consumption profile:** The consumption profile by month of the year is shown in the graph area of Figure 45, and detailed consumption is shown in Table 32. The month with the lowest consumption is colored green and the month with the highest consumption is colored yellow.

   As for the previous building, the electricity consumption profile shows low consumption in the winter months and increasingly high levels as the academic year starts. Consumption is high in peak summer seasons but fluctuates according to occupancy rates and summer schedules. Although different years show almost the same consumption profile, consumption fluctuated in the years 2012, 2013 and 2014. In 2011 and 2015 when the building's fluctuation decreased, the graph almost settled down. This fluctuation during 2012, 2013 and 2014 was caused by a fluctuation in the number of students being served. Before 2011 and in 2015, this number of students was constant compared to other years as the university witnessed high enrollment levels after 2011.

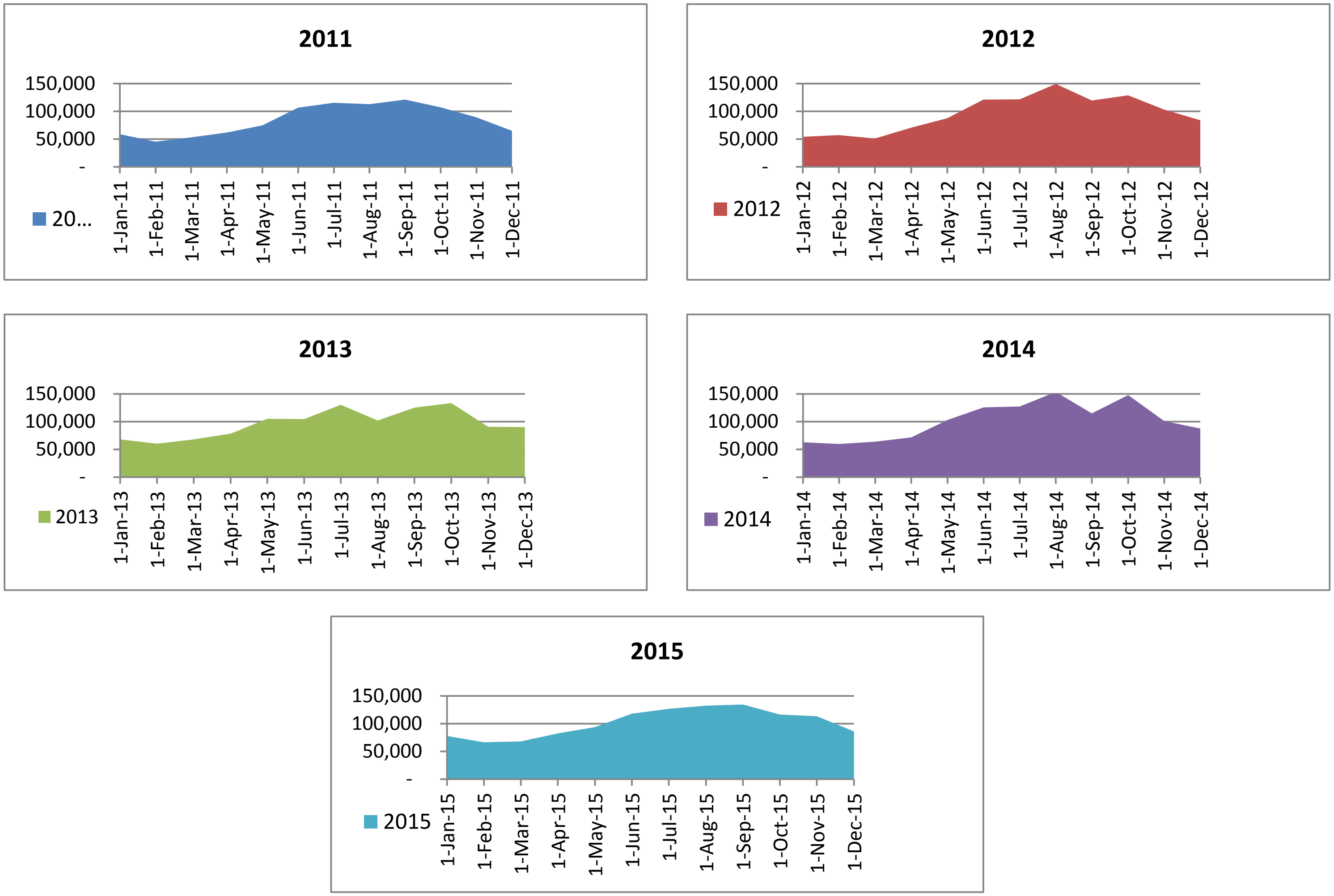

Figure 42.: Electricity consumption profile from 2011 to 2015

Table 32.Monthly electricity consumption for registration and admission building (2011-2015) kwh/month

Min	
Max	

QU- Registration and admission building											
2011											
1-Jan	1-Feb	1-Mar	1-Apr	1-May	1-Jun	1-Jul-	1-Aug	1-Sep-	1-Oct	1-Nov	1-Dec
58,610	45,180	53,160	61,780	74,890	106,820	115,310	112,940	121,180	107,310	88,960	64,670
2012											
1-Jan	1-Feb	1-Mar	1-Apr	1-May	1-Jun	1-Jul-	1-Aug	1-Sep-	1-Oct	1-Nov	1-Dec
53,870	57,230	51,100	70,540	87,430	121,000	121,620	149,770	119,850	129,000	102,940	84,000
2013											
1-Jan	1-Feb	1-Mar	1-Apr	1-May	1-Jun	1-Jul-	1-Aug	1-Sep-	1-Oct	1-Nov	1-Dec
68,010	60,250	68,150	78,500	105,090	104,850	130,390	102,180	125,240	133,480	90,700	90,190
2014											
1-Jan	1-Feb	1-Mar	1-Apr	1-May	1-Jun	1-Jul-	1-Aug	1-Sep-	1-Oct	1-Nov	1-Dec
62,920	59,690	63,990	71,390	103,090	126,100	127,330	153,720	114,930	148,010	101,110	87,590
2015											
1-Jan	1-Feb	1-Mar	1-Apr	1-May	1-Jun	1-Jul-	1-Aug	1-Sep-	1-Oct	1-Nov	1-Dec
77,700	66,340	67,770	82,300	93,730	118,050	127,050	132,500	134,600	116,320	113,280	86,280

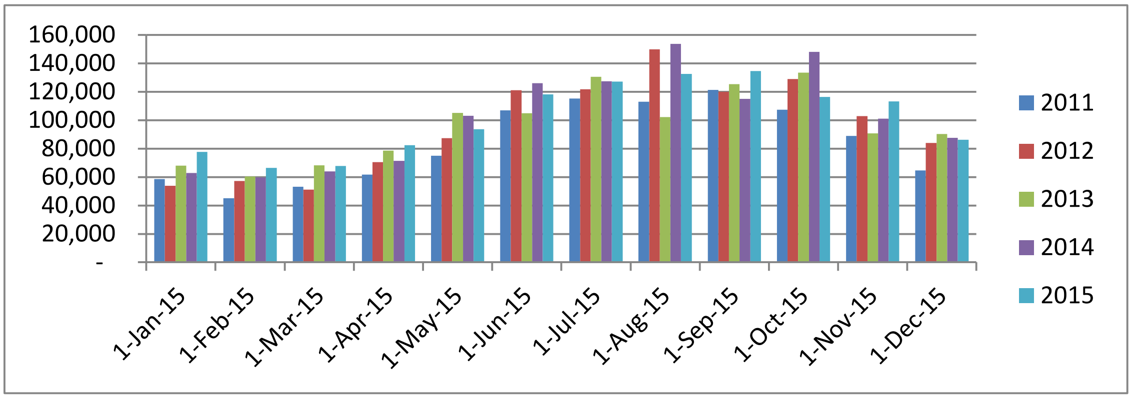

Figure 43.Electricity consumption registration and admission building from (2011 to 2015) kwh/month

3. **Electricity base load:** 45,180kWh was recorded in 2011 for one month, and this was the lowest consumption. However, this load was not repeated in any of the following years.

4. **EUI:** A similar case to that of the Men’s Foundation building is recorded in the registration building, as it is an office building as well. Both buildings show high EUI levels similar to those of classroom buildings. Moreover, the level is higher than the standard EUI by 10 degrees or more.

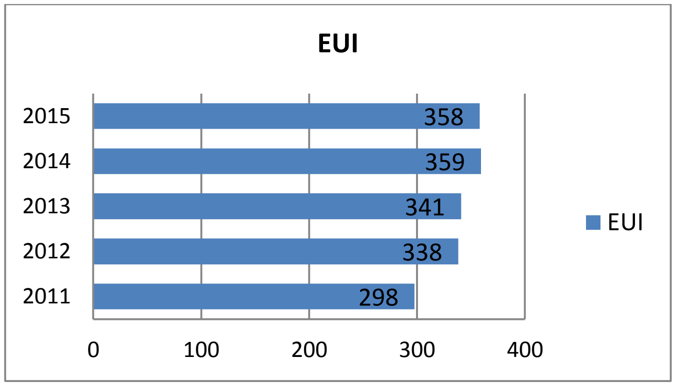

Figure 44.EUI values for admission and registration building from 2011 to 2015

5. **Consumption per occupant:** consumption per occupant is extremely high between 5000-6000kWh/year per occupant as shown in figure 48 which is more than double the benchmark value which is between 2,000 and 2,700 kWh/year per occupant.

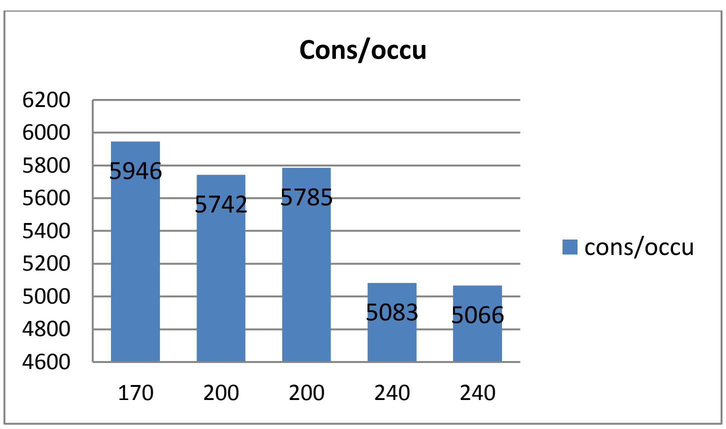

Figure 45.Consumption per occupant according to the number of occupants

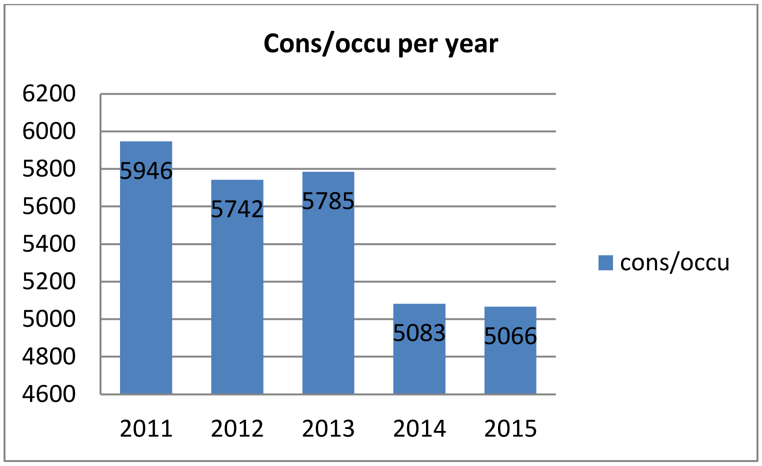

Figure 46.Consumption per occupant in years (2011-2015)

6. **Maximum load and minimum load according to monthly records:** The minimum and maximum consumption loads for this building were close to those of other classroom buildings. They were 45,180kWh/month and 153,720kWh/month, respectively. This raises an important query, too: Why is the building consuming almost the same amount as classroom buildings do?

To investigate this high level of consumption in the registration building, the researcher used two methods. The first was to ask mechanical engineers and technicians about the high level of consumption, and the second was to investigate occupant satisfaction with the building in terms of AC. Investigating both sides, those of the FM and the occupants, is essential when figuring out the gap in this loop.

Engineers and technicians stated that the set point in this building was between 20 °C and 22 °C in summer, and it sometimes decreased to 19 °C according to some occupants' requests. In winter, the set point was between 22 °C and 24 °C. Twenty occupants were interviewed, and most interviewees mentioned that the building was too cold, especially in summer. They said they were not satisfied with this and that they complained a lot.

An interview method was chosen to investigate this issue, since interviews give more space for discussion and understanding of a situation. The questions were as follows:

1. What is the set point for the AC in the building (in winter and summer)?

2. Do you have access to the AC thermostat?

3. How do you feel in winter and summer?

4. Are you satisfied with the AC level in terms of heat and coolness?

The answers of interviewed occupants are listed in the table below number 33-a and 33- b.

Table 33-a .Answers of interviewed occupants in admission and registration building

#	Name	Office type	Set point for the AC in		access to the AC thermostat	Who do you feel?		Are you satisfied with the AC level	
			winter	summer		winter	summer	winter	summer
1	Nora	Open space/cubical	25	19	No	Good	Cold	satisfied	Not satisfied
2	Aisha	Open space/cubical	24	19	No	Warm	So cold	satisfied	Not satisfied
3	Reem	Open space/cubical	24	18	No	Good	Cold	satisfied	Not satisfied
4	Dana	Open space/cubical	23	20	No	Warm	So cold	moderately	Not satisfied
5	R.A	Open space/cubical	25	19	No	Warm	So cold	satisfied	Not satisfied
6	Najla	Open space/cubical	22	20	No	Warm	So cold	satisfied	Not satisfied
7	Kaltham	Private office	24	19	No	Good	So cold	moderately	Not satisfied
8	Hadeel	Private office	23	19	No	Good	Cold	moderately	Not satisfied
9	Ilham	Private office	25	20	No	Warm	Cold	moderately	Not satisfied
10	Ibrahim	Open space/cubical	24	20	No	Warm	Cold	satisfied	moderately

11	Abdullah	Private office	23	20	No	Warm	Sometimes Cold	satisfied	moderately
12	Abdulrah man	Private office	24	20	No	Warm	Sometimes Cold	satisfied	moderately
13	H.A	Private office	24	19	No	Good	Sometimes Cold	satisfied	Not satisfied
14	M.M	Open space	24	19	No	Good	So cold	satisfied	Not satisfied
15	L.E	Open space	24	21	No	Good	So cold	satisfied	Not satisfied
16	A.A	Open space	24	20	No	Good	So cold	satisfied	Not satisfied
17	M.R	Open space	23	18	No	Good	Most of the time cold	satisfied	Not satisfied

Table 34-b .Answers of interviewed occupants in admission and registration building

18	N.N	Open space	23	18	No	Good	Cold	satisfied	Not satisfied
19	A.L	Open space	23	18	No	Good	Most of the time cold	satisfied	satisfied
20	O.P	Open space	23	18	No	Good	Cold	satisfied	Not satisfied
Results		14/20 in Open space/cubical	Betwee n 23-25	Betwee n 19-21	No	Good	All answers between cold and so cold	16/20 satisfied	16/20 Not satisfied

Case study 6: QU library building

The library building commenced operation in 2014 for both male and female students. It has a high number of occupants, at about 2,000, long operation hours and vast volume in terms of space. Its floor area itself is 45,251 m^2. Data available in table 35.

1. **Electricity consumption profile:** The consumption profile by month of the year is shown in the graph area of Figure 50, and detailed consumption is shown in Table 35. The month with the lowest consumption is colored green and the month with the highest consumption is colored yellow.

The electricity consumption profile shows approximate base load consumption in the winter months. The graph area starts with low consumption in winter months and increasingly high levels in September and October as the academic year started. A high fluctuation rate is recorded across months and years, and this is because there is no fixed schedule of activities in the building as activities are flexible in the library. Furthermore, the number of occupants is not fixed and changes daily.

2. **Electricity base load:** 357,310 kWh is the minimum load recorded. While this is considered to be the minimum for this building, other buildings did not reach this value. This high consumption is caused by the huge area and volume of this building.

3. **Total consumption per year:** Total consumption per year is shown in Table 35.

Table 35.Electricity consumption for library building and other building data

Year	SUM	Area	EUI	occupant	cons/occu
2014	5,114,990	45251	113	2,000	2,557
2015	5,828,240		129	2,000	2,914

4. **EUI and consumption per occupant:** EUI for the library is much less than the ENERGY STAR standard, and this is an indication of good energy performance. However, this EUI value must be monitored, as it is increasing. The consumption per occupant value is slightly above the benchmark value of 2,700 kWh per occupant per year. Conversely, this is still reasonable but needs to be monitored in the future.

Table 36.Monthly electricity consumption for library building (2014-2015) kwh/month

Min	
Max	

Library building											
2014											
1-Jan	**1-Feb**	**1-Mar**	**1-Apr**	**1-May**	**1-Jun**	**1-Jul-**	**1-Aug**	**1-Sep-**	**1-Oct**	**1-Nov**	**1-Dec**
384,570	363,270	401,370	407,110	382,330	421,200	367,040	481,240	357,310	489,620	498,850	561,080
2015											
1-Jan	**1-Feb**	**1-Mar**	**1-Apr**	**1-May**	**1-Jun**	**1-Jul-**	**1-Aug**	**1-Sep-**	**1-Oct**	**1-Nov**	**1-Dec**
572,250	515,070	433,470	518,350	438,350	476,060	527,660	494,060	486,450	483,640	443,220	439,660

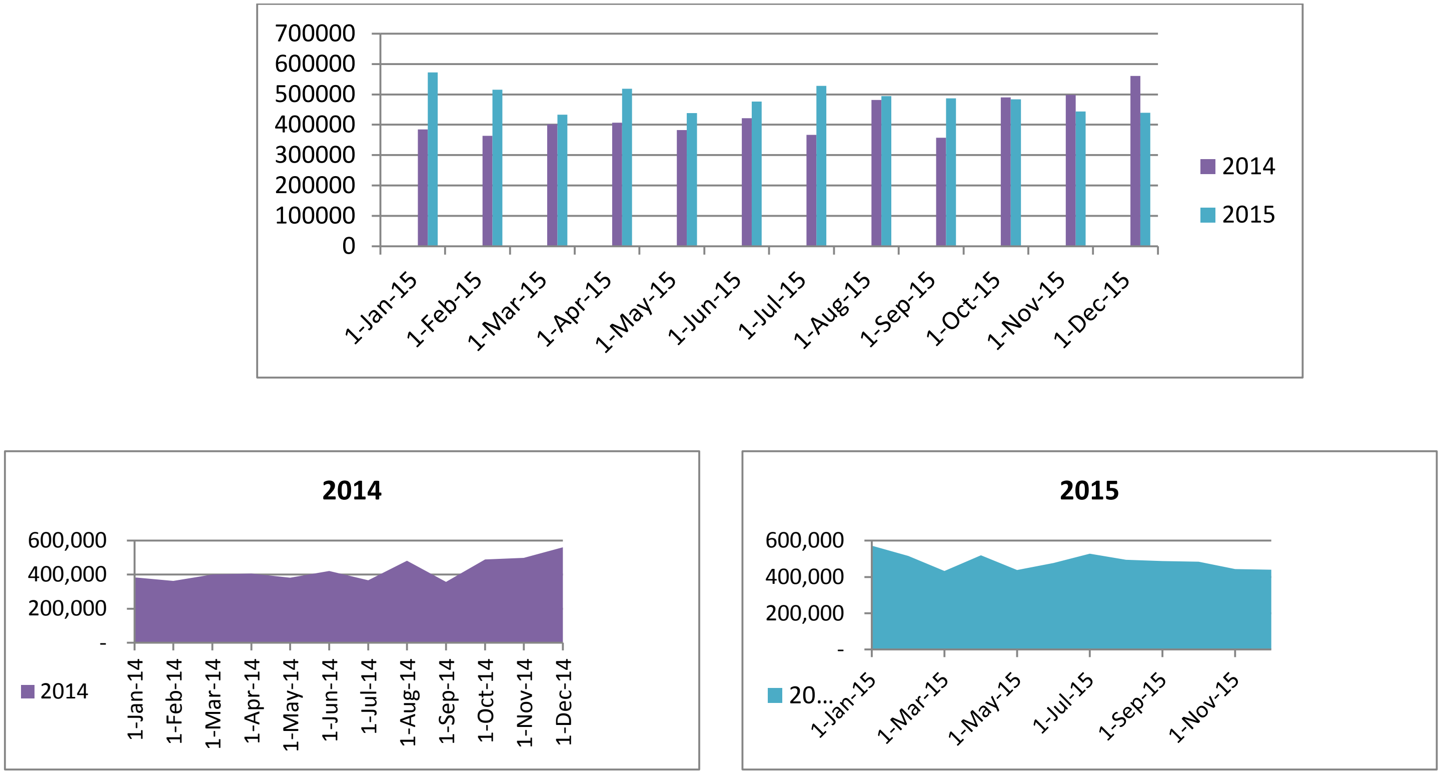

Figure 47.Electricity consumption profile for library building from (2014 to 2015) kwh/month

Campus X

An investigation of energy consumption patterns at this campus begins by looking into the energy consumption for 2015 on a monthly basis, as shown in Table 37. Table 38 shows the total electricity consumption for each building, EUI, consumption per occupant and other building details. Then the area graph is generated from this record to investigate consumption patterns across different months.

Table 37. Electricity consumption for buildings in campus X 2015

Jan-15	Feb-15	Mar-15	Apr-15	May-15	Jun-15	Jul-15	Aug-15	Sep-15	Oct-15	Nov-15	Dec-15
Campus X- W - College Building											
1,006,661	1,673,262	1,016,147	1,369,327	1,396,582	1,246,049	1,555,490	1,326,469	1,183,260	1,546,810	1,351,349	1,307,481
Campus X –U-College Building											
18,903	24,256	23,308	28,688	32,782	37,521	38,441	38,976	36,844	40,711	28,237	22,236
Campus X -Male housing											
3,656	3,800	20,860	501,750	619,300	532,690	473,610	466,320	518,610	700,980	591,030	619,490
Campus X - Female housing											
40,748	49,917	30,644	41,650	314,010	383,160	325,060	312,480	332,170	380,260	425,900	361,950

Table 38.Electricity data for campus x buildings

Building Code	**Total electricity consumption kwh/year 2015**	**Area** m^2	**EUI** kwh/m^2	**Building Type**	**Energy star standard** for EUI kwh/m^2	**Number of occupant**	**Co/Oc** kwh/oc/year
Campus X- W	15,978,887	48,879	**326**	Medicine College	383	1044	15,305
Campus X -U	370,903	12,488	**29**	Design College	383	400	927
Campus X -Male housing	5,052,096	26,860	**188**	Male Housing	216	NA	NA
Campus X - Female housing	2,997,949	26,860	**111**	Female Housing	216	NA	NA

Case study 7: Campus X, W College

Since this building is a medical college, it has numerous labs that are about 34 active research laboratories. It also has a huge volume and area (48,879 m^2). All of these resulted in high energy consumption in total for the year 2015 of 15,978,887 kWh. However, the EUI value was not large and satisfied the standard with 326kWh/m^2asmentioned in table 39.

The consumption per occupant is considered to be very high, but it should not be compared with other college buildings, since this building has many labs which require another type of operation energy. The activities and uses of a space are highly recommended to be investigated when studying building energy performance. What can be concluded from this is that the EUI of this building does not tell everything about its energy consumption.

Looking to the area graph at figure 51, W College had high fluctuation values between ups and downs. Peaks occurred at the start of each semester in January, July and October.

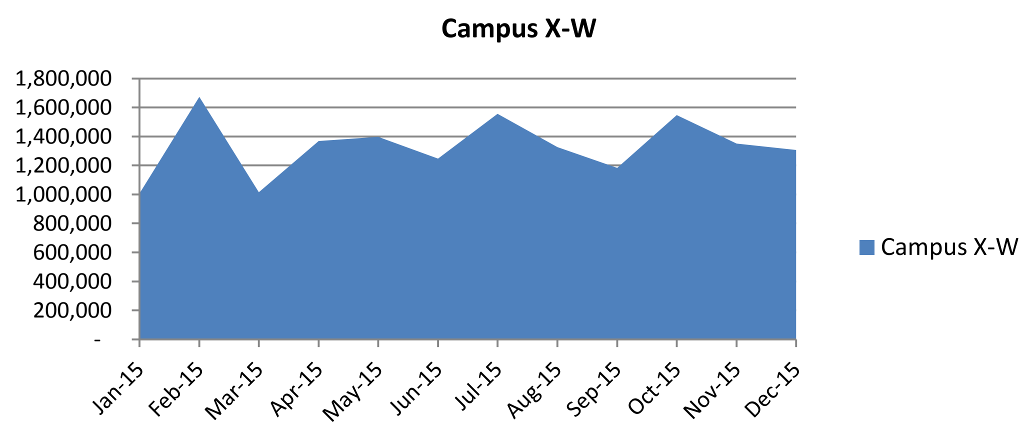

Figure 48.Electricity consumption for W college in 2015 kwh/month

Case study 8: Campus X, U College

This building is a design college with few labs. Although it has a huge volume and area (12,488 m^2), its energy consumption is very low, about 370,903 kWh in 2015. This might be explained by the small number of occupants, which is 400. The EUI value is extremely small, at 29. This low EUI was found in similar case studies during the literature review, and it satisfies the standard by being much less than 326 kWh/m^2.

The consumption per occupant is also considered to be very low, at 927 kWh per occupant per year. Looking at the area graph, U College obtained a semi-normal distribution around June. One major peak lies between September and October.

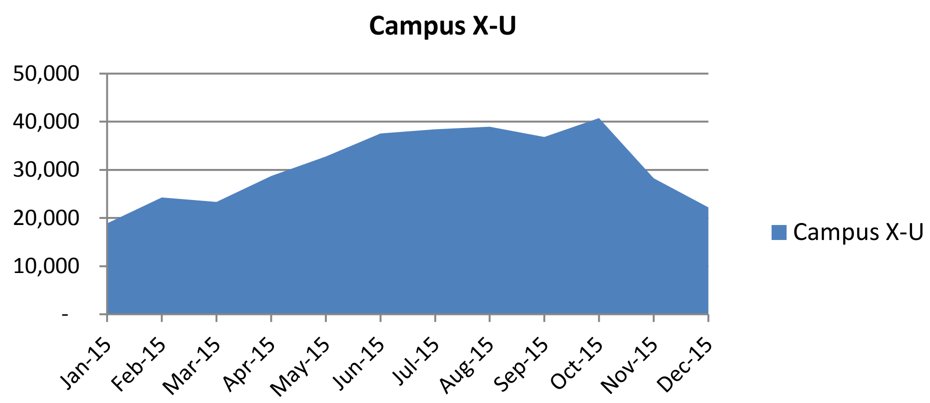

Figure 49.Electricity consumption for U college in 2015 kwh/month

Case study 9: Campus X, male and female housing

Both dormitories have similar designs and areas of 26,860 m^2. They are also both LEED platinum certified. The number of men is higher than the number of women, but no exact numbers could be found. Looking to the area graph in Figure 53, it is very obvious that the distribution is almost the same, while the consumption is much higher in the male side by about 1.6 times, since there are more men than women in the complex. The graph in Figure 53 illustrates that both area charts overlap to recognize the difference between both housing as a result of the difference in number of occupants only.

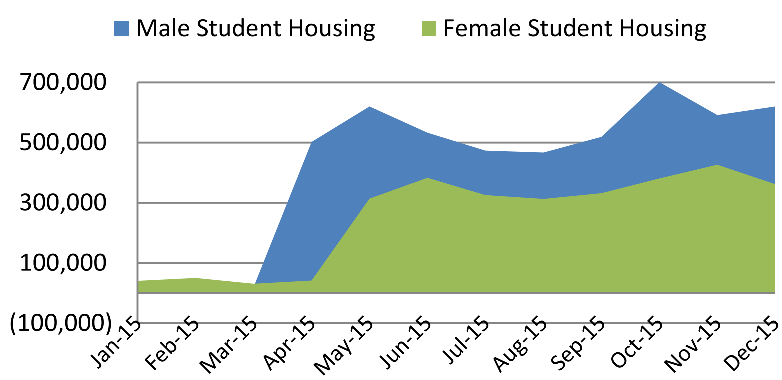

Figure 50.Electricity consumption for male and female housing

Consumption is minimal during the winter and reaches high levels during April, October and November, as those are the months when semesters start. The graphs of figures 54 and 55 display a reduction in consumption through summertime, and this is a result of the vacation during which most students travel back home. EUI for both is less than the ENERGY STAR standard, and both represent good energy performances refer to table 37.

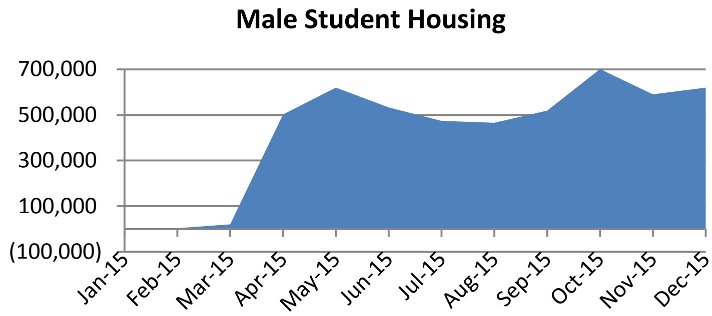

Figure 51.Electricity consumption for male student housing during 2015

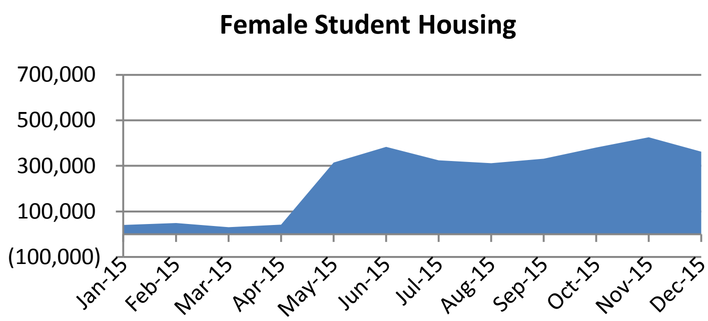

Figure 52,Electricity consumption for female student housing during 2015

Case study 10: Campus Y, sport college building

Campus Y sport building consists of class room building and purpose halls for training as it is a sport academy, so the activity in this college is mixed between education and sport and this what makes the mechanical team to decrease the AC set point to reach 18, this result in high electricity consumption as shown in table 38 which represents the consumption for year 2015. The Energy Star lacks the EUI value for such a building since there is no category for sport academy venues. Table 39 is showing the building data and represents the value of consumption/ occupants that spears to be high compared to other college buildings.

Table 39. CampusY– electricity consumption for year 2015

Dec'14	**Jan'15**	**Feb'15**	**Mar'15**	**Apr'15**	**May'15**	**Jun'15**	**Jul'15**	**Aug'15**	**Sep'15**	**Oct'15**	**Nov'15**	**Total**
540930	559440	583260	510580	555160	558720	592790	10551700	565310	10615550	616630	622520	26872590

Table 40.Campus Y building data

Building Code	**Total electricity consumption kwh/year 2015**	**Area** m^2	**EUI** kwh/m^2	**Building Type**	**Energy star standard** for EUI kwh/m^2	**Number of occupant**	**Co/Oc** kwh/oc/year
Campus Y- A	26872590	33,580	800.2558	Education Class room	NA	400	67181

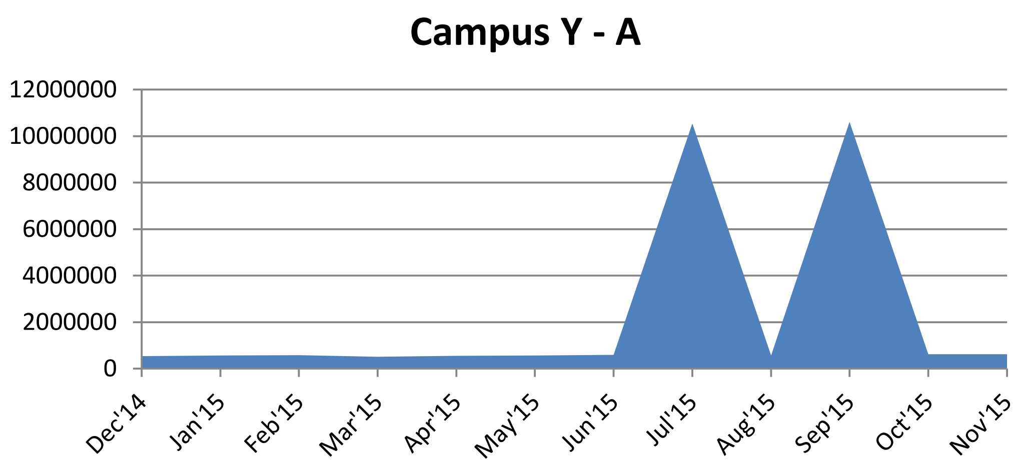

Figure 53.Electricity distribution for Aspire Academy

Water consumption

Water consumption is extremely high in Qatari campuses compared to other foreign campuses and to the European standard, table 40 illustrates this water consumption. Reasons for this high consumption refers to 3 main causes as illustrated from interview stage:

- Lack a culture of water conservation
- Lack of technologies and strategies to reuse and recycle the water in district scale.
- The ablution is consuming water as people are not awarded and not considering water consumption while doing ablution in the Arab world.

Water consumption at Qatar university is higher than other Qatar campuses and this may refer to the fact that all the university buildings are connected in one meter and this make it difficult to determine the location in case any problem or water leak happen . Refer to table 41 for water consumption details at the studied buildings.

Table 41.Water consumption in studied campuses

Water consumption in studied campuses											
College	*QU Women's Sharia College*	*QU Women's Engineering College building*	*QU Women's Foundation building*	*QU Men's Foundation building*	*QU admission and registration building*	*QU library building*	*Campus X- W*	*Campus X -U*	*Campus X -Male housing*	*Campus X - Female housing*	*Campus Y- W*
Total water consumption /Year 2015 (M^3)	The whole university in one meter 1,483,960						28,895	1,939	30,749	32,975	13015
Consumption/occupant	74.1						28	5	NA	NA	33
Water consumption standard	20 m^3 / occupant according to European commission (DG ENV) water efficiency standards										

Essential and general findings for the energy analysis

- The calculated EUI for most buildings is a good indication of energy consumption performance, as most buildings scored EUI less than the ENERGY STAR standard. Although superb EUI values were scored by most buildings on different campuses in Qatar, this may not reflect the real energy consumption performance. As a result, there is a need to investigate energy consumption per occupant. As an additional step, this consumption was calculated based on the number of occupants, not building floor area. Table 42 summarizes the data.

- KWh per occupant per year is high. Benchmarking with foreign universities shows that Qatari campuses consume 1.5 to 2 times more than foreign campuses/occupants.

- Consumption has increased throughout the years for all buildings, and as a result, EUI is increasing as well, but consumption per occupant is inversely decreasing.

- Peak consumption falls between June and August.

- The lowest consumption falls in January and February.

- Changing buildings' functions affects consumption highly.

- The type of HVAC system used contributes highly to energy conservation as illustrated in table 42.

- Office buildings consume energy as much as classroom buildings, contrary to what was expected, since the EUI for office buildings is meant to be lower because of lower number of occupants.
- EUI does not take into consideration essential parameters to evaluate energy performance. Essential parameters to be taken into account are building type, function, occupancy and HVAC system. As a result of this, EUI alone cannot assess energy performance.

Table 42.Final comparison between colleges in Qatar

Final comparison between colleges in Qatar											
College	QU Women's Sharia College	QU Women's Engineering College building	QU Women's Foundation building	QU Men's Foundation building	QU admission and registration building	QU library building	Campus X- W	Campus X -U	Campus X -Male housing	Campus X - Female housing	Campus Y- W
Total consumption Year 2015 kWh	1,504,670	1,306,450	2,054,590	1,211,680	1,215,920	5,828,240	15,978,887	370,903	5,052,096	2,997,949	26,872,590
Type of HVAC system	DX	Chillers	DX	DX	DX	Chillers	Chillers	Chillers	Chillers	Chillers	Chillers
Building Area m2	3954	12684	4491	3750	3395	45251	48,879	12,488	26,860	26,860	33,580
Number of occupants	530	660.00	1,400	170.00	240.00	2000	1044	400	NA	NA	400
EUI kwh/m2	380.54	103.00	457.49	323.11	358.15	129	326	29	188	111	NA
Co/Oc/year	2,839.00	1,979.47	1,467.56	7,127.53	5,066.33	2,914	15,305	927	NA	NA	67181.4

Analysis and results

Survey – questionnaire analysis

The sample of this survey/ questionnaire was 105 participants, distributed between FM and non FM personals; however all of them work in building sectors. Participants were from different organizations, the researcher focused more to get FM teams from QU, QF and Aspire campuses. Moreover, the researcher tried to find databases of design/construction personnel and this was by contacting responsible people at QGBC (Qatar Green Building Council) and Qatar Green Leaders.

Participants' general information

The survey was taken by participants with different engineering backgrounds ranging from MEP engineers to architects, civil and finally facility technicians. Mechanical Engineers were the highest in the participant list with a percentage of 26.6%, followed by electrical and civil engineers with 20% and 16% respectively. Architects were the fourth group with 12% and technicians the lowest with 3%.The highest level of education that participants held is listed in table 43.

Table 43. Highest level of education for survey participants

Q4- What is the highest level of education you have completed?	
Answer Options	**Response Percent**
Did not attend school	0%
Graduated from high school	1%
Graduated from college	75%
Master degree	18%
PhD Degree	2%
Other (please specify)	4%

The survey was taken by participants with different lengths of years of experience ranging from one year to 15 plus. The highest percent was for the group of 5-10 years' experience with the percentage of 28% followed by the category more than 15 years of experience with 26% and this can be shown from the pie graph in figure 57. The lowest percentage of years of experience was 1-3 years which calculated to 13%.

Q6 asks about the experience in the current company. The group with the highest percent at 39% was the 3 to 5 years' experience group, while the second to lowest was the 10 to 15 years' experience group at around 7%; there were very few participants that had more than 15 years' experience, so their experience group had almost zero percent, figure 58 shows this distribution.

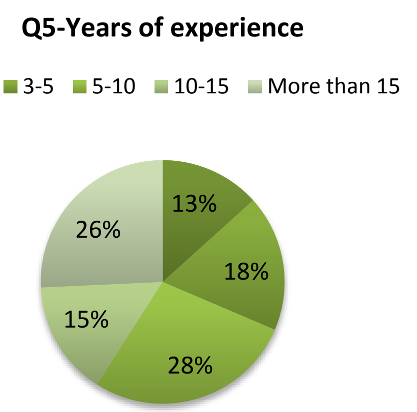

Figure 54. Participants' years of experience

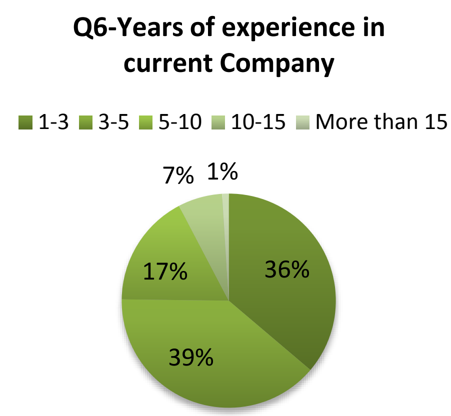

Figure 55. Participants' experience in current company

In sustainability experience question, the number of participants with no experience at all was high scoring 46% and the percentage of participants with 1-3 years scored 28%, so in total more than 73% of participants were with low experience in sustainability. These results demonstrated low numbers of engineers with plentiful experience in the field of sustainability, for more illustrations see pie chart figure 59.

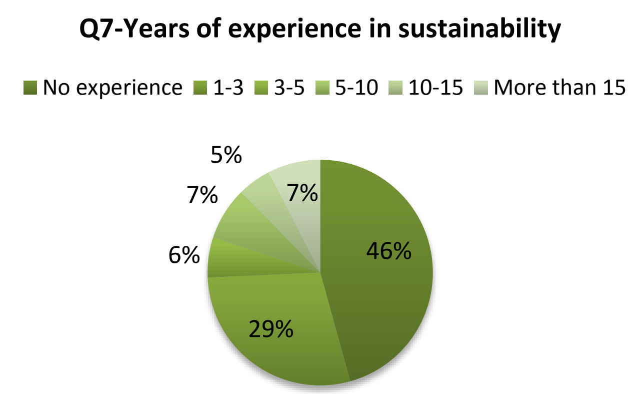

Figure 56.Participants' years of experience in sustainability

For **Q8** more than two thirds (64%) of the participants answered ‘yes’ to whether or not they currently work in facility management, while the rest answered ‘no’ to the question. In total about 64% are working in FM at the moment, see doughnut chart in figure 60.

Figure 57. Percentage of participants who are working in FM

For the question, “Is the information that’s delivered from the contractor to the operation team enough?" around 60 percent answered affirmatively, however, about 22% said that only part of the information was given and needed more maintenance instructions and manual inputs. As for the rest, it was either difficult to recover such information or no such information was provided. Table 44 shows those percentages.

Table 44.Percentages for the answer of Q9

Q9-According to your work in FM, is the project delivered from the contractor to the operation and maintenance team with enough information and plans?	
Answer Options	**Response Percent**
Yes, enough information is provided	60%
It's difficult to recover and maintain the information when needed	8%
No enough information provided	8%
Part of information is given but Operation and Maintenance instructions and manual input is still required	23%
Didn't reach to the stage of operation and maintenance, I don't know if I have enough information	2%

Involvement of FM in early project phases

Q10 in figure 61 was posed to FM personnel and the majority said that the facility management team had limited involvement in the design phase, at about 61%. Moreover, approximately 21% answered that there is no involvement from FM for the design phase, and this reflects the lack of integration between FM and the design /construction team. When analyzing the preferences of the FM team, it became apparent that they would actually like to participate from the design phase as seen from their answers for Q11, figure 62**.** Around 57% chose to be involved from the design phase and 16% from the construction phase. The neglected percentage for this question was about 2% for those who would like to be involved after project completion.

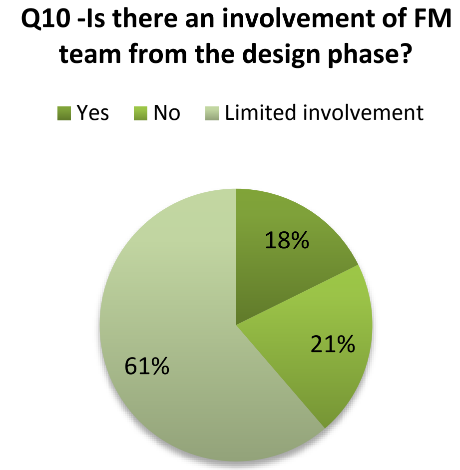

Figure 58.Involvement of FM team from the design phase

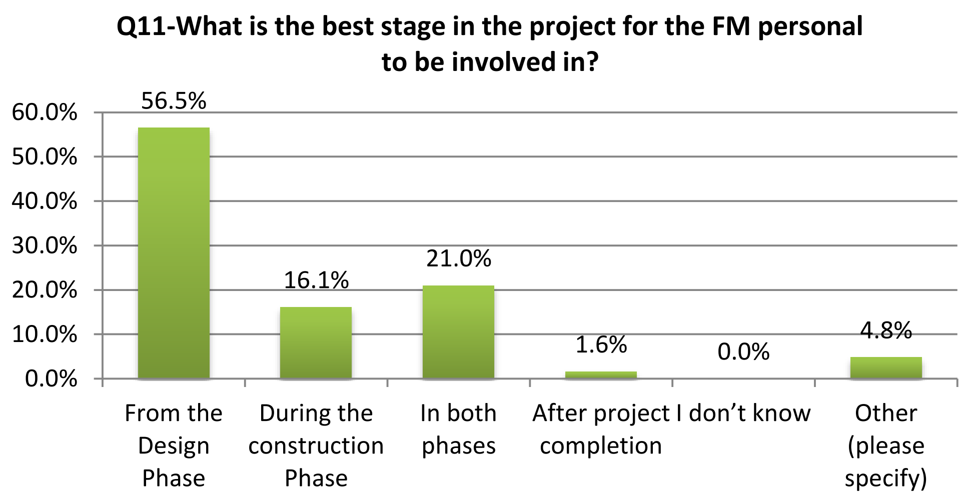

Figure 59. The best stage in the project for the FM personal to be involved in

On the other hand, the design/construction participants that made up around half of the total number of participants indicated in their answers that they involve the FM team in the project during the construction/design phase to a limited extent, however about one fifth of the participants indicated that they don't involve the FM team at all; comparatively, another fifth indicated that they do involve the FM team from the construction/design phase. Table 45 illustrates answers for this question.

Table 45. Involving FM team during design/construction phase

Q27-Are you involving the facility management team in the project during design/construction phase?	
Answer Options	**Response Percent**
Yes , we involve the facility management team from design and construction phase	16.7%
Yes, but limited involvement	60.0%
No, we don't involve them	16.7%
I don't know	6.7%

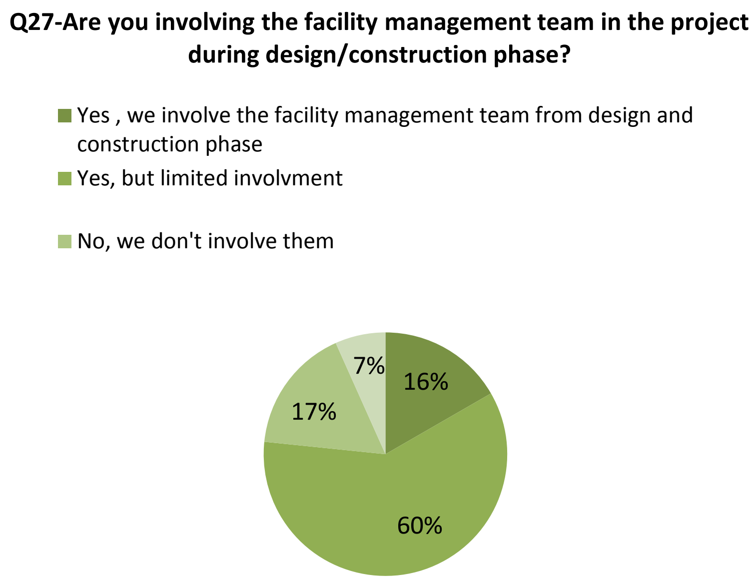

Figure 60.Percentages of involving FM team in the project during design/construction phase

For Q12 shown in figure 64 about more than a third of the *FM personnel* sample answered that they had been involved in the “after completion phase”32%, on the other hand 13% involved from the design phase.

‘’ during the construction phase’’ about 34% had selected this choice so that they are involved only during the construction phase, finally 11% were involved in both phases , this reflects in general the poor involvement of the FM team from the design phase .

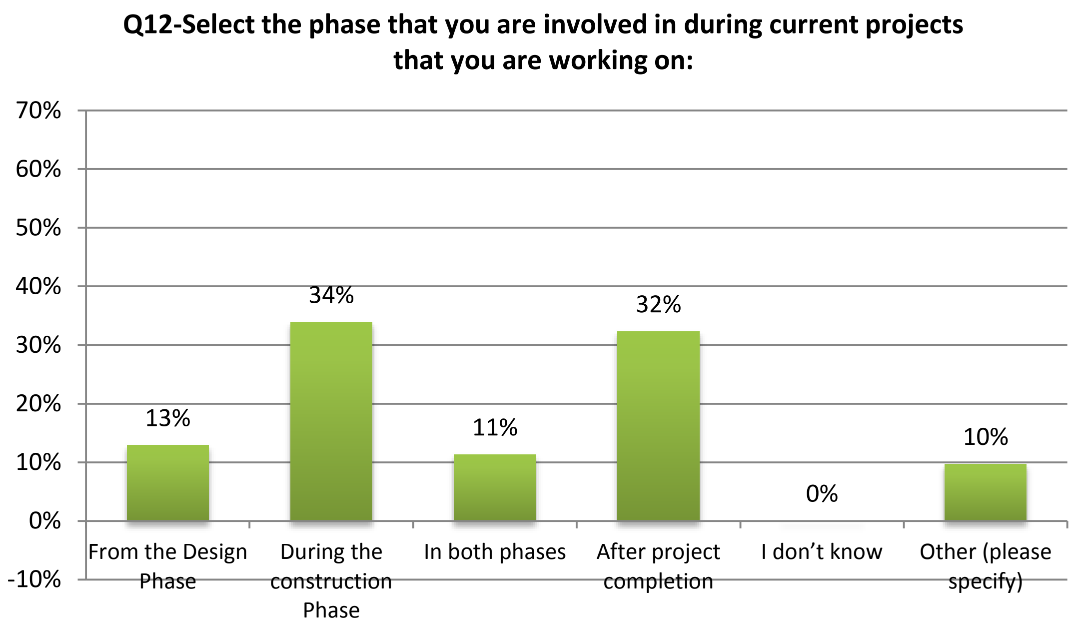

Figure 61.FM personnel involvement during current projects

On the other side the *non FM personal* were asked the same question and most of them were involved from the construction phase. The non FM personal answers are shown in figure 65. The vast majority believe that FM team's involvement in the construction/design phases is important.

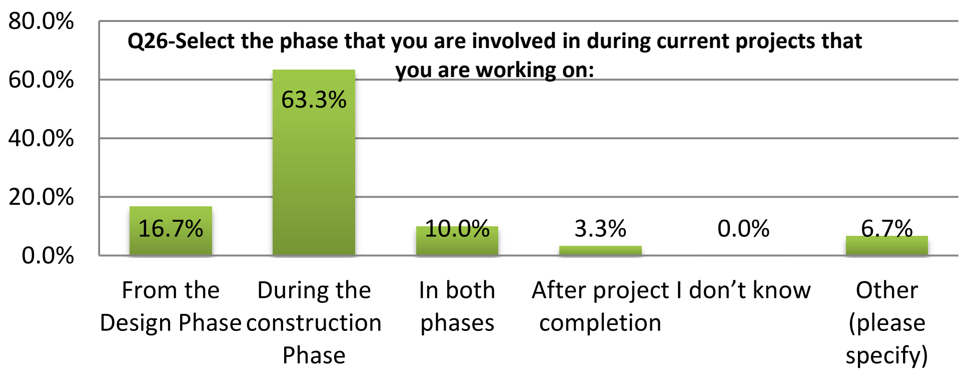

Figure 62.Non FM personnel involvement during current projects

Sustainability training

More than three quarters of FM participants (approximately 77%) did not receive any kind of training or workshop regarding sustainability in their current organization; this refers to Q13 in figure 66. On the other hand, for question 14 the vast majority (about 89%) were interested in receiving training in sustainability practices this illustrates in figure 67; moreover about 73% expected sustainability practices or policies to impact on their jobs in the near future in Q15, see figure 68.

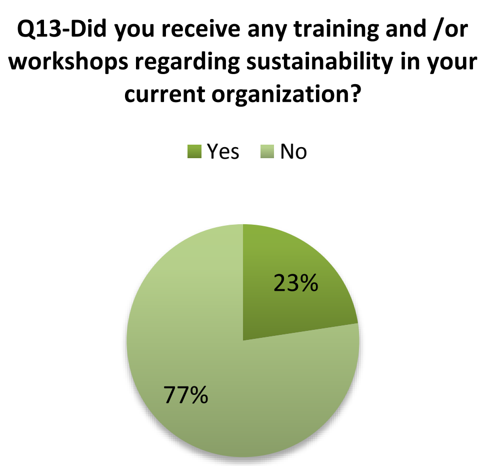

Figure 64.Percentage of FM who didn't receive sustainability training

Figure 63.Percentage of FM would be interested in being trained in sustainability

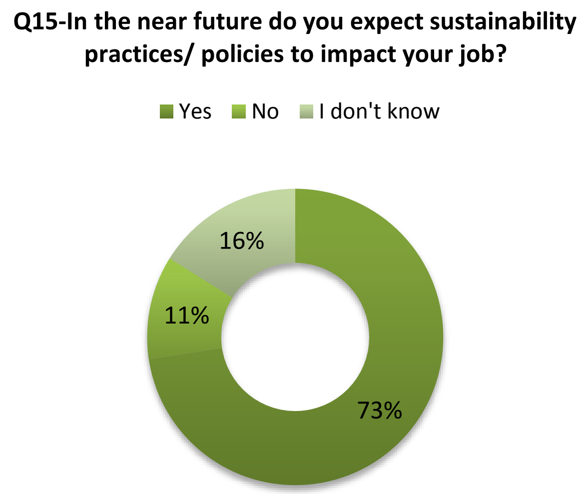

Figure 65. Percentage of FM expecting sustainability to impact future job

The non-FM organizations take more care of sustainability training as they conduct training for their staff. Table 45 summarizes the findings of Q29 – the question reveals that 47% of the staff had received sustainability training.

Table 46.Sustainability training for non-FM personals

Q29-Did you receive any training and /or workshops regarding sustainability in your current organization?	
Answer Options	Response Percent
Yes	47%
No	53%

Figure 66.Sustainability training for non FM personals

Importance of sustainability for FM industry

For the question asking FM personals about the importance of sustainability for the FM industry, answers were distributed in different ranks starting from 58% who believe that sustainability will be very important for the FM industry. The second rank for the important category showed 35%, for natural 6%, see figure 70. The same question was repeated with non-FM personal; their answers were almost the same and are shown in table 47.

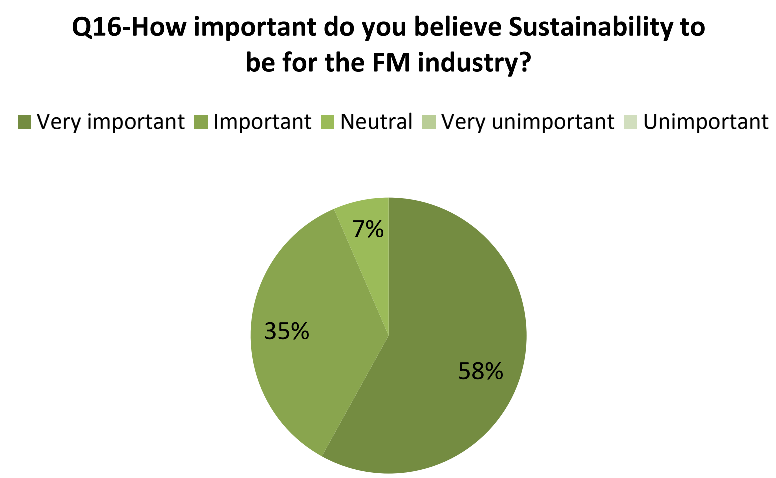

Figure 67.Importantance of Sustainability to the FM industry –FM personal answers

Table 47.Importantance of Sustainability to the FM industry –non FM personal answers

Q28- How important do you believe Sustainability to be for the FM industry?

Answer Options	FM Response Percent	Non FM Response Percent
Very important	58%	46%
Important	36%	50%
Neutral	7%	3%
Very unimportant	0%	0%
Unimportant	0%	0%

Sustainability strategies and practices

Around half of the participants did not have a separate department for sustainability in their current organizations, meanwhile within the third that said they had, very few of them said that their organizations are planning to have sustainability departments; 3% from the rest of the participants answered with 'I don't know'. See figures 71 and 72.

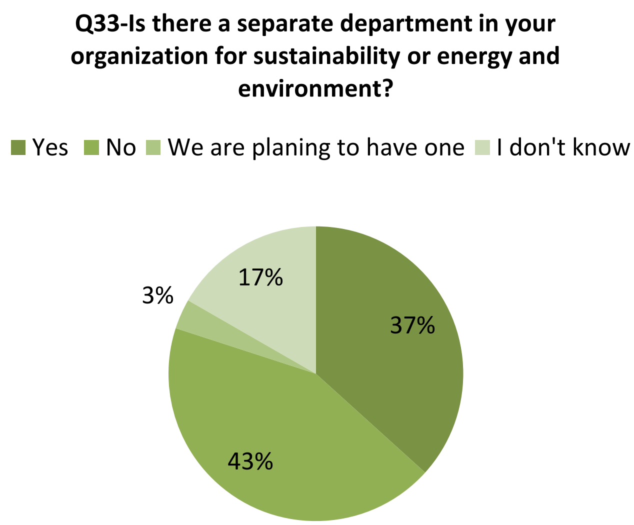

Figure 68.Percentage of separate sustainability department in non FM organizations

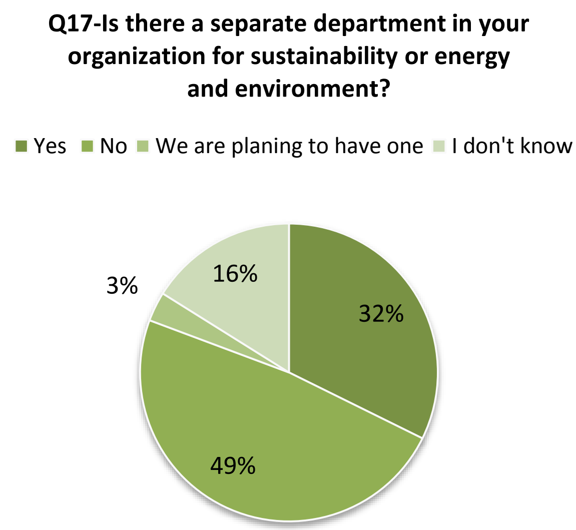

Figure 69.Percentage of separate sustainability department in FM organizations

Table 48 shows a comparison in implementing sustainability practices between FM and non-FM organizations. For FM more than the third 33% ,said they had sustainability practices at their organizations but not yet implementing it, and a quarter said that their organizations had plans to implement sustainability practices in either one years' time to five years' time. This indicates that there is no effective implementation for sustainability practice, and it is at its beginning stages.

Table 48.Comparison of sustainability practicesbetween FM and non FM organizations

Are there sustainability practices at your organization or is it recently implemented?		
Answer Options	**FM team Response Percent**	**Non-FM team Response Percent**
We currently implement sustainability practices and have sustainability policy	11%	37%
We have sustainability plans and policies but we are not yet implementing it	34%	17%
In one year's time we will implement sustainability practices	16%	10%
In five years' time we will implement sustainability practices	11%	7%
No plans to implement sustainability practices	5%	17%
N/A	23%	

More than half of the participants (63%) had no annual sustainability report in their organizations and 18% didn't know at all, these were the responses gathered from FM personnel. The non-FM personal responded 'yes' 10% of the time for Q19. Those percentages are shown in the pie charts at figures 73 and 74.

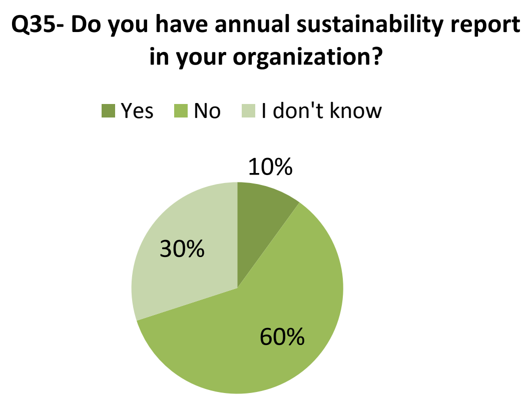

Figure 70.Percentage of non- FM participants that has sustainability report

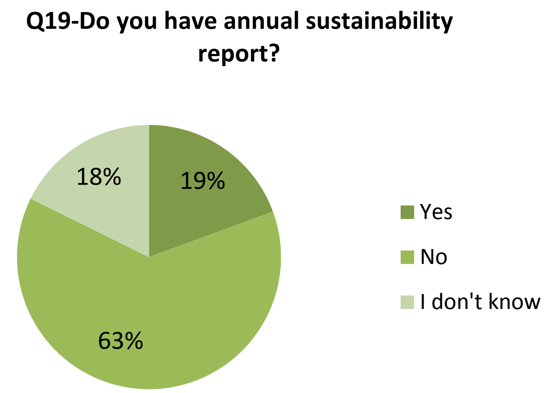

Figure 71.Percentage of FM participants that has sustainability report

When asked to rate their knowledge on sustainability approximately 16% of the participants rated their knowledge at a low level (grade 1), while 69% percent rated it at a medium distributed scale (between grade 2-3) , about 5% chose grade 5. On this question those with the lowest level of knowledge (level 1) were excluded from answering the following questions in order to avoid biased results. See figure 75.

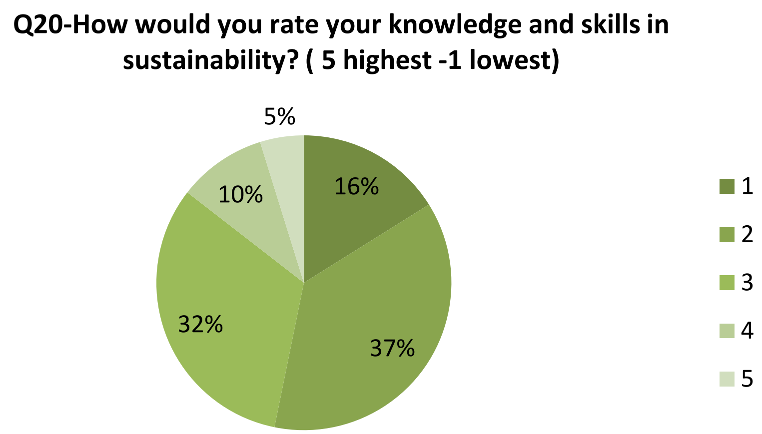

Figure 72.Participants'sustainability knowledge

Green accreditations

Answers for Q21 and Q39 were scattered, thirty one percent did not have LEED buildings in their campus, however about half of the participants said they had between two to six LEED buildings, As shown on table 48, 19% prefer to say that they don't know since they are not sure about their answers. Qatar Foundation's FM participants showed an increase in the percentage of answers for this question since Qatar Foundation had many LEED buildings; the list of those buildings is attached in Appendix C. This went along with participants from Qatar University because they have a plan to accredit existing buildings as LEED. More than two third of non-FM responses had no LEED buildings. Those percentages are illustrated in table 49.

Table 49.LEED certified buildings' percentage

Q21-How many LEED buildings do you have in your campus or intended to have within 2 years?		
Answer Options	**FM-Response Percent**	**Non-FM Response Percent**
No LEED buildings	31%	57%
1	2%	3%
2-4	23%	13%
4-6	17%	0%
I don't know	19%	17%
Other (please specify)	8%	

The majority of participants (about 77%) did not have any green accreditation; however LEED GA was the highest accreditation earned for 13% of participants and there were 4% with GSAS accreditation. The response count is shown in table 50 to compare the number of persons that have accreditation. For both FM personnel and non-FM personnel there are 14 participants for one and 15 participants for the other respectively.

Table 50.Distribution of participants who had green accreditation

Q22-Q39DO you have any Green accreditation? please select the applicable ones:				
Answer Options	**FM- Response Percent**	**Response Count**	**Non-FM Response Percent**	**Response Count**
NO	77%	40	63%	19
Yes, LEED GA	14%	7	7%	2
Yes, LEED AP	2%	1	10%	3
Yes , GSAS	4%	2	23%	7
Other (please specify) ISO accreditations	8%	4	10%	3

Sustainability knowledge

In Q23 and Q25 the participants ranked the sustainability aspects according to their choice of importance from the most important to least as shown in table 51. This rank reflects different concerns and preferences between the FM and design / construction team. The first proprieties of FM teams are energy and water efficiency, followed by waste management and the indoor environment. While the design/ construction team ranked waste management as first priority and material management as last.

Table 51. Participants' rank for sustainability aspects from most important to least

FM personal	Non-FM personal
Energy efficiency	Waste management
Water efficiency	Water efficiency
Waste management	Indoor Environment Quality
Indoor environment	Energy efficiency
Material management	Site Quality
Cultural aspects	Cultural aspects
Site quality	Material management

Table 52.shows the average rating for those aspects and figure 77 shows the bar graph of FM vote.

Rank the following aspects according to their importance in achieving sustainability on FM (considering 7 the highest and 1 the lowest)- Number can't be duplicated - **Rating Average**

Answer Options	**FM-Response**	**Non-FM-Response**
Energy efficiency	6.42	4.64
Water efficiency	5.49	5.77
Waste management	4.03	7.36
Indoor Environment Quality	3.46	5.76
Site Quality	3.13	4.28
Material management	3.45	3.42
Cultural aspects	3.32	4.00

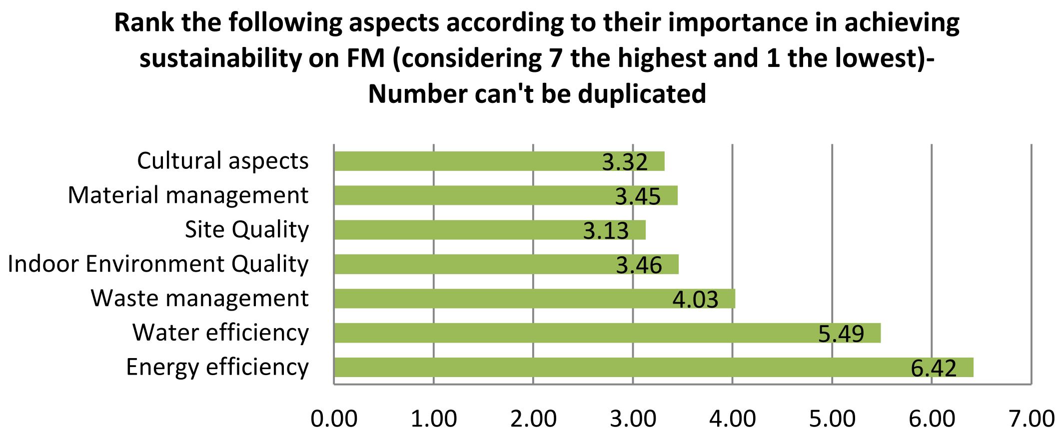

Figure 73.Average rating for sustainability aspects-FM vote

Opinions were split regarding the main obstacles for implementing sustainability, amongst others lack of training, high initial cost, no clear standardized tools and lack of good sustainability case studies were the main obstacles. In fact, most of the obstacles gained a very close rating average. Most participants strongly agreed about the listed impediments. FM personnel gave 'lack of culture sustainability' the highest vote, while non-FM staff gave it as the second highest vote. The highest rating average for non-FM employees was lack of training. This can be shown and summarized in figures 77 and 79. Tables 54 and 55 are showing answers counting for each choice.

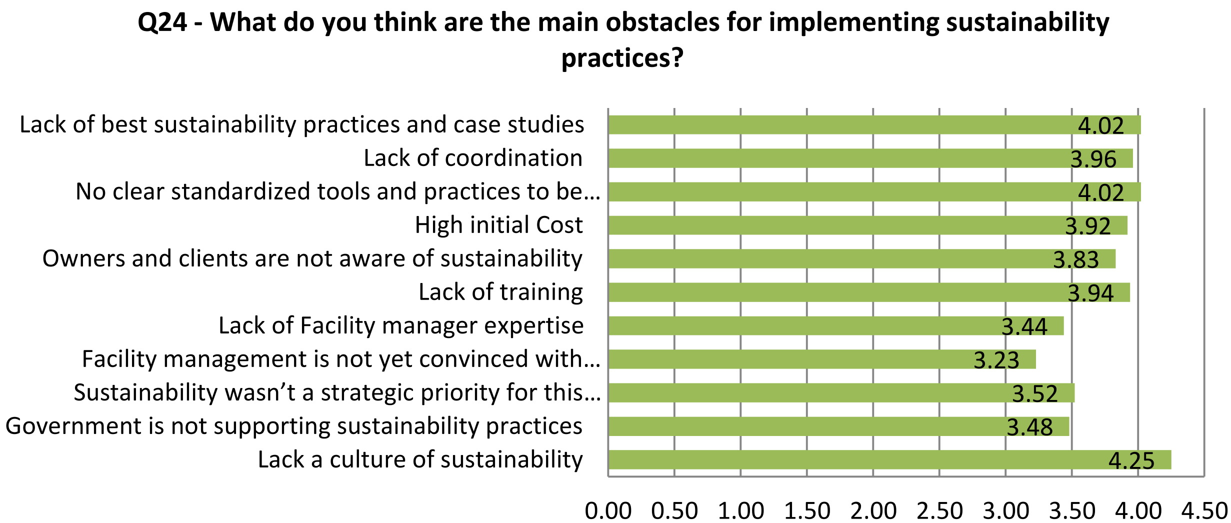

Figure 74.Main obstacles for implementing sustainability practices - FM response

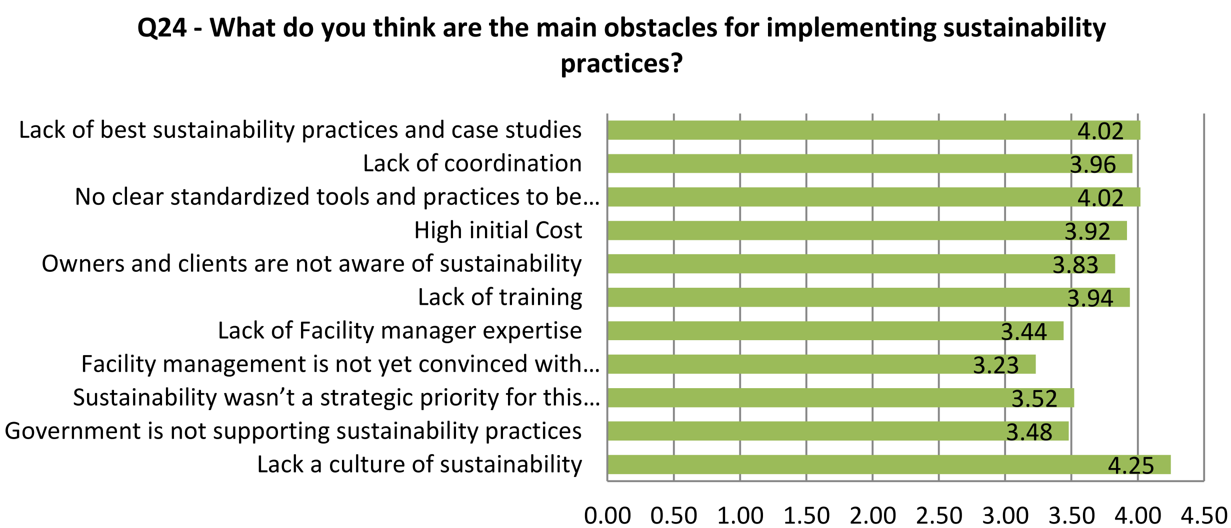

Figure 75.Main obstacles for implementing sustainability practices - FM response

Figure 76 Main obstacles for implementing sustainability practices - non FM response

Table 54.Answers counting for each choice-FM answers

Answer Options	Strongly Disagree	Disagree	Neutral	Agree	Strongly agree	Rating Average
Lack a culture of sustainability	0	0	6	24	18	4.25
Government is not supporting sustainability practices	1	9	11	20	7	3.48
Sustainability wasn't a strategic priority for this organization	0	10	10	21	7	3.52
Facility management is not yet convinced with sustainability benefits	3	11	11	18	5	3.23
Lack of Facility manager expertise	2	11	8	18	9	3.44
Lack of training	0	5	6	24	13	3.94
Owners and clients are not aware of sustainability	2	5	5	23	13	3.8 3
High initial Cost	1	3	7	25	12	3.92
No clear standardized tools and practices to be followed	0	2	8	25	13	4.02
Lack of coordination	0	3	8	24	12	3.96
Lack of best sustainability practices and case studies	0	1	10	24	13	4.02

Table 55.Answers counting for each choice-non FM

Answer Options	Strongly Disagree	Disagree	Neutral	Agree	Strongly agree	Rating Average
Lack a culture of sustainability	0	3	2	13	12	4.13
Government is not supporting sustainability practices	2	10	7	8	3	3.00
Lack of training	0	0	3	16	11	4.27
Owners and clients are not aware of sustainability	1	4	0	16	9	3.93
High initial Cost	1	4	4	16	5	3.67
No clear standardized tools and practices to be followed	1	7	2	11	8	3.62
Lack of coordination	0	2	2	18	8	4.07
Lack of best sustainability practices and case studies	1	3	5	15	6	3.73

Sustainability has several benefits according to the participants' answers for **Q25**. It minimizes usable consumption, energy and water consumption as well. The ranks are shown in the following table 56 and bar chart figure 80:

Table 56.Sustainability benefits according to participants' rank from most important to least

Answer Options	Rating Average
Minimize energy consumption	7.36
Minimize water consumption	5.77
Enhance resources utilization	5.76
Reduce degradation of environment	5.73
Reducing trash and pollution	5.53
Minimize usable consumption	4.64
Increase users service and satisfaction	4.28
Improve the overall understanding of the building	4.00
Makes work more interesting	3.42

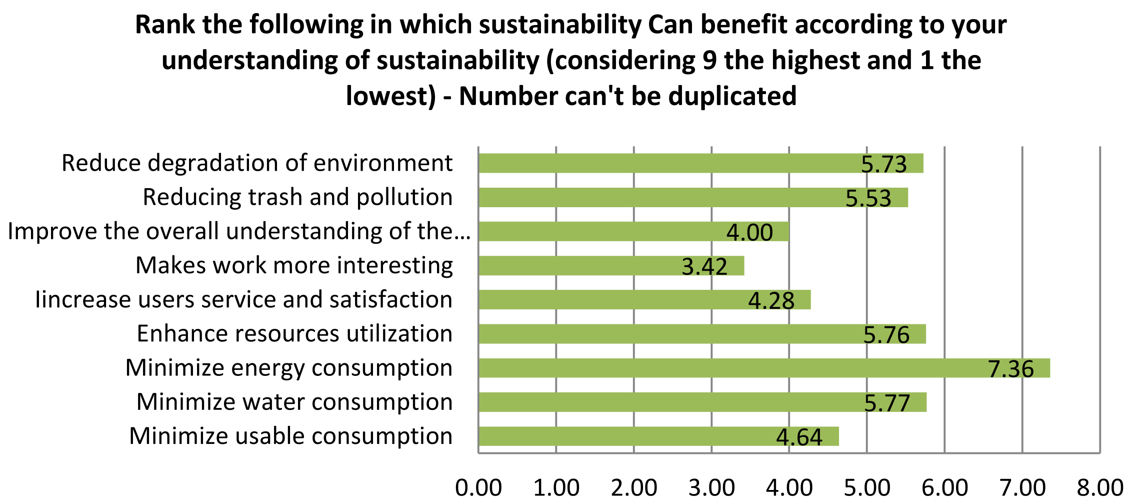

Figure 77.Sustainability benefits according to participants' rank

Buildings volume and sustainability

60% of participants from the non-FM team in thought that some buildings in Qatar are oversized, while 23% also thought that most buildings are oversized. 40 percent commented that a height of 4.5m in some buildings is suitable, however 43 percent said that it is more than what’s necessary.

The majority concluded that the height of buildings will effect energy consumption as they will need more AC.

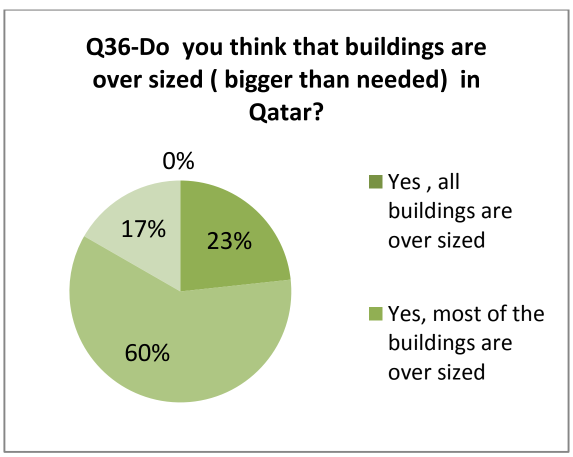

Figure 79.Non -FM personal answers regarding buildings size

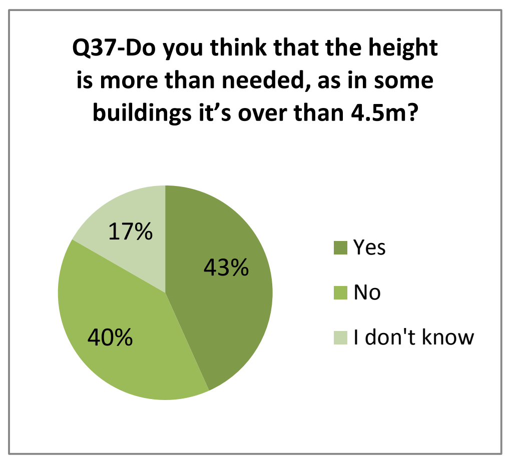

Figure 78. FM personal answers regarding buildings size

Maintenance and sustainability

Preventive and corrective maintenance are the most applied types of maintenance on the participants' buildings and campuses, then by a wide margin reactive and predicative maintenance takes place as illustrated by Q45 in figure 83. 94% of the participants are applying preventive maintenance currently .All of the participants think that preventive maintenance is important and 80 percent feel it is very important. See figures 83, 84 and 85 below.

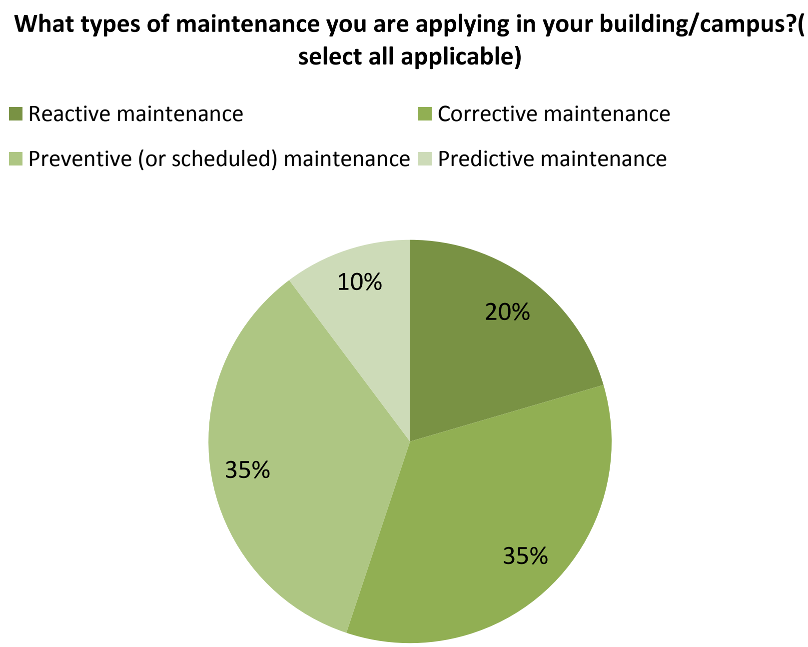

Figure 80.Types of maintenance applied by FM

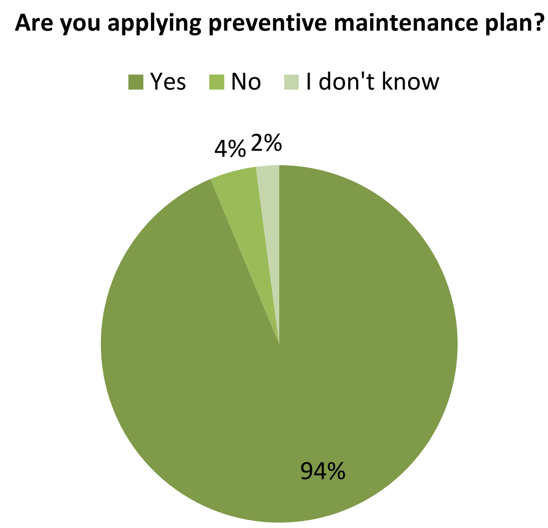

Figure 81.Percentages of PPM applied by FM

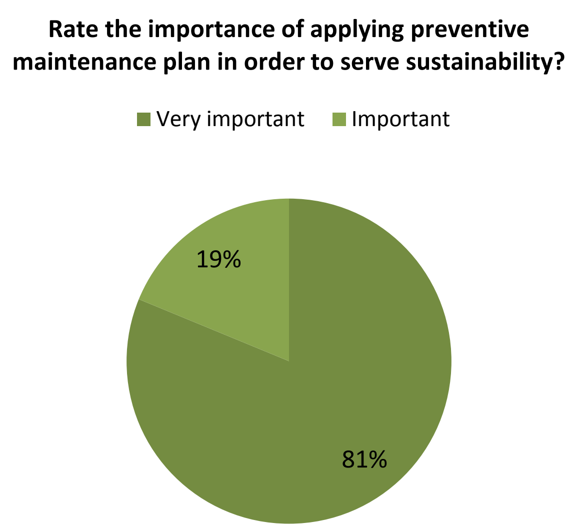

Figure 82.The importance of applying PPM

FM departments

About 21% of the participants are working currently in HVAC services departments, 19% are working in electrical services, 12% in electrical systems services and 12% in civil services. Figure 86 illustrates this distribution.

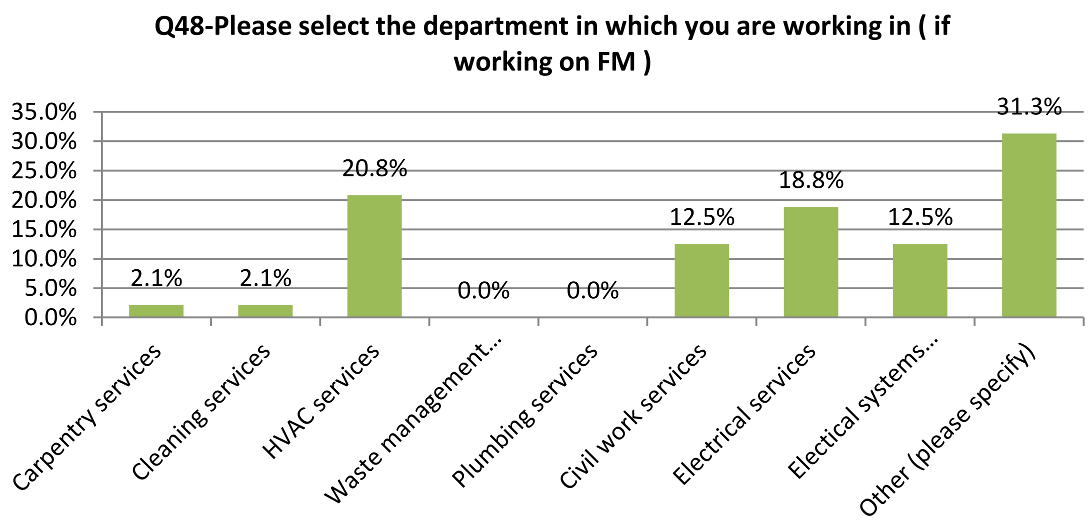

Figure 83.Distribution of FM personals according to the department

HVAC services questionnaire

A water cooled chiller is one HVAC system used on all campuses that the participants work on, while packaged unit, split unit system and air cooled chiller systems are used on 80 percent of the campuses. VRF and VRV are assigned by half of the participants which by filtering represents 2 campuses, Aspire and QF are using it only figure 87 shows percentages of t HVAC type.

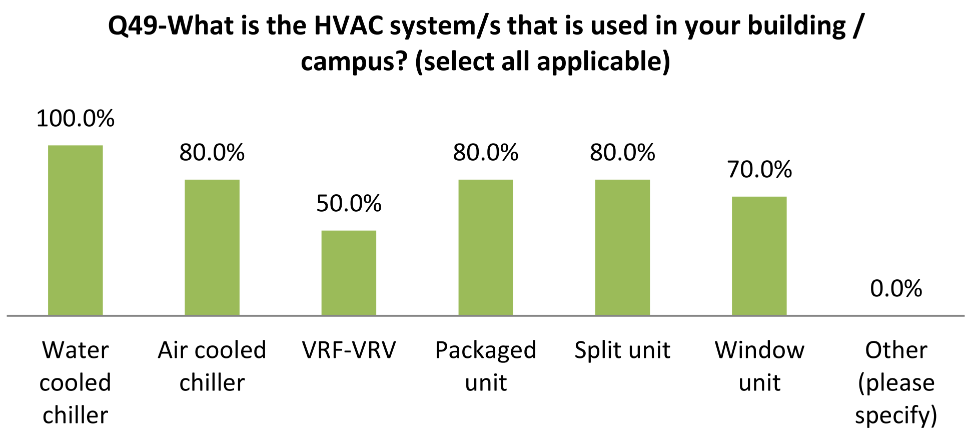

Figure 84.Types of HVAC system

Heat recovery is the most widely used technology in HVAC to reduce energy consumption and meet thermal comfort; economizer and CO_2 sensors come in at second place. This was shown in Q50 answers, see figure 88.

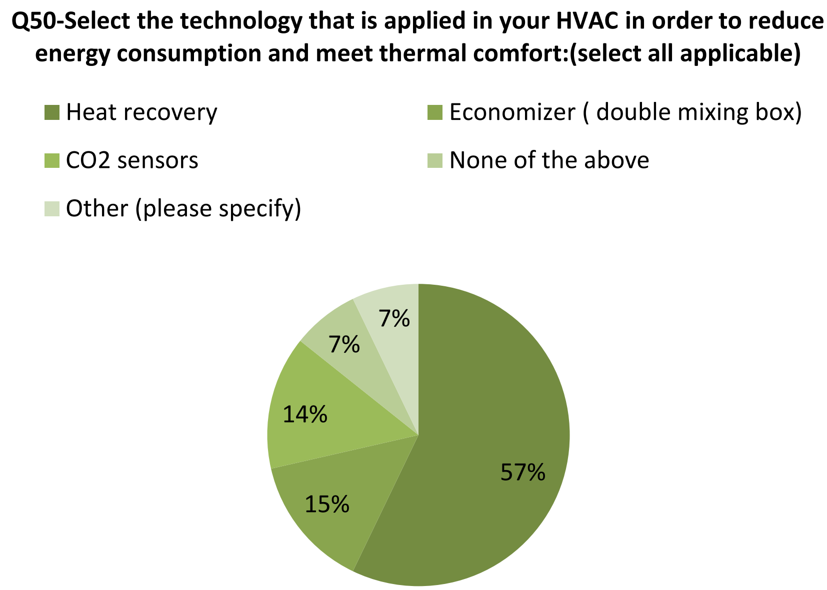

Figure 85. HVAC technology applied to reduce energy consumption

A third of the participants are planning to install HVAC technologies in case they don't have any, while half of them don't know whether or not they are going to. 80 % have never changed HVAC systems in their buildings those results are for, figures 89 and 90 display this distribution. A feasibility study before carrying out upgrades or a retrofit is considered by the vast majority to be necessary (90%). HVAC metering is available in some buildings at 50% of the time and in all buildings at 30%, see figure 91.

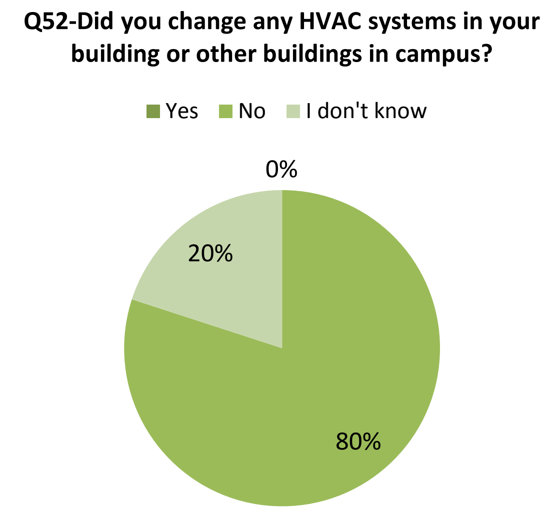

Figure 86.Changing the HVAC system

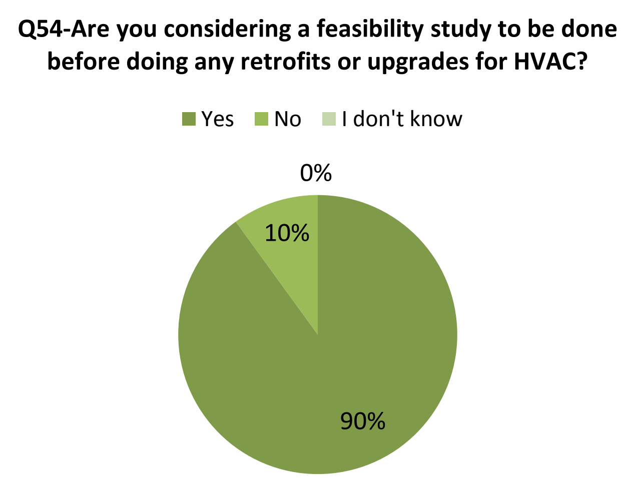

Figure 87.Conducting a feasibility study to upgrade HVAC

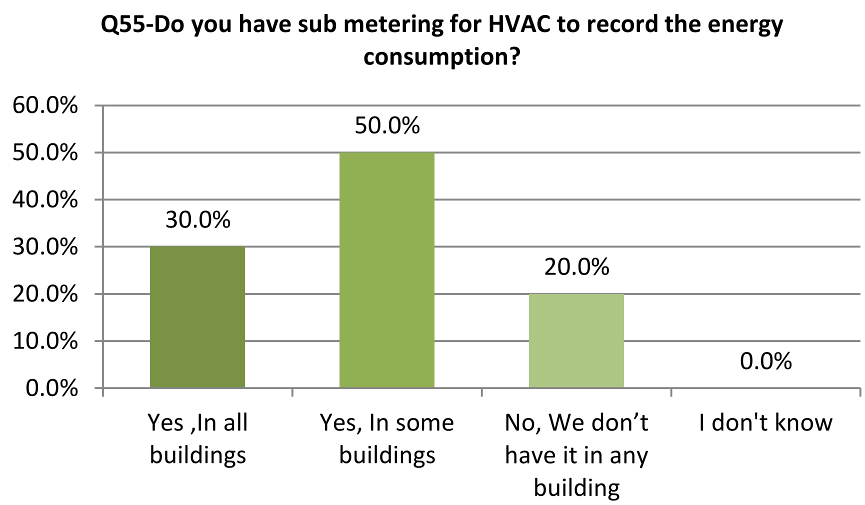

Figure 88. Sub metering for HVAC percentages

50% of participants use chlorofluorocarbon based refrigerants in heating, ventilation and air conditioning and are willing to replace them - for more illustration refer to Graphs for 92 and 93.

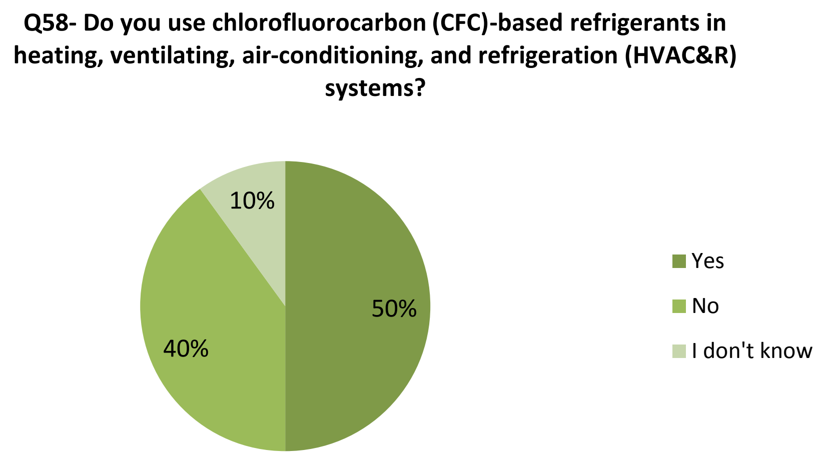

Figure 89.Percentage of participants using CFC

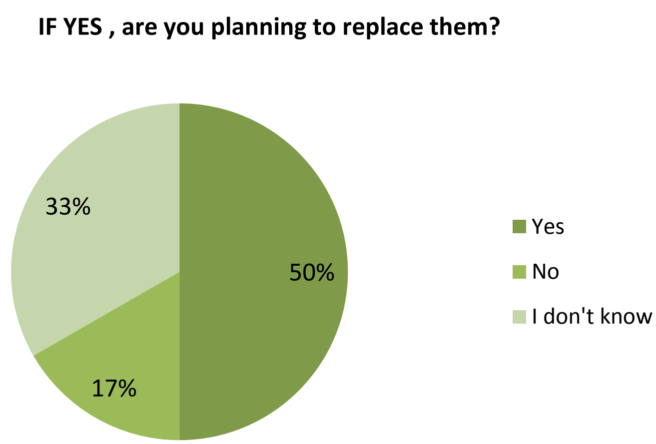

Figure 90.Replacing of CFC

The following questions are comparable since they were asked of both electrical and mechanical engineers, both of them answered in different ways since they do not all work at the same organization.

50% of mechanical engineers answered that they are setting the AC temperature between 22 - 24 degrees Celsius; 18 - 20 degrees Celsius was the next favorable range with a medium percentage of 30%.

46% of electrical engineers chose 18-20 C for the AC in buildings during summer. During winter the favorable range chosen by the majority was 22 to 24, see figures 94 and 95.

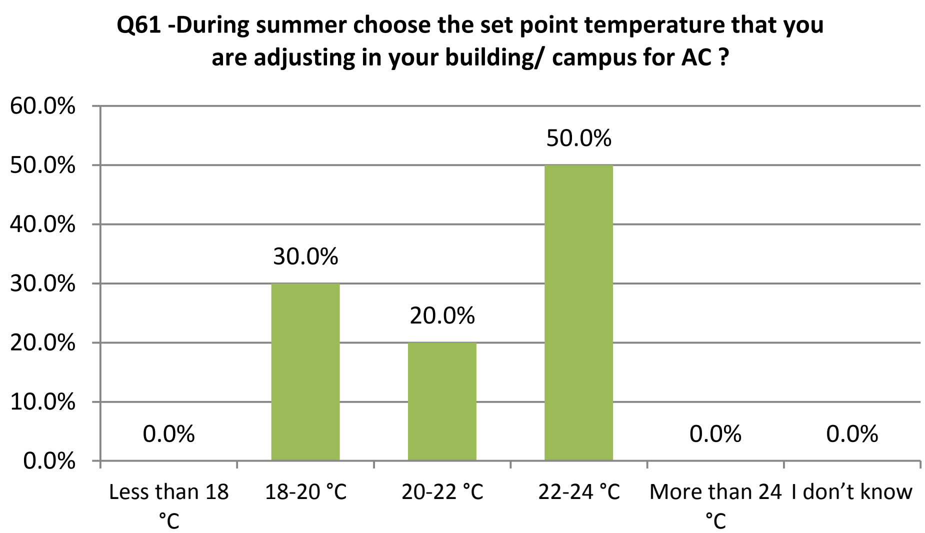

Figure 91. AC set point during summer –Mechanical Engineers answer

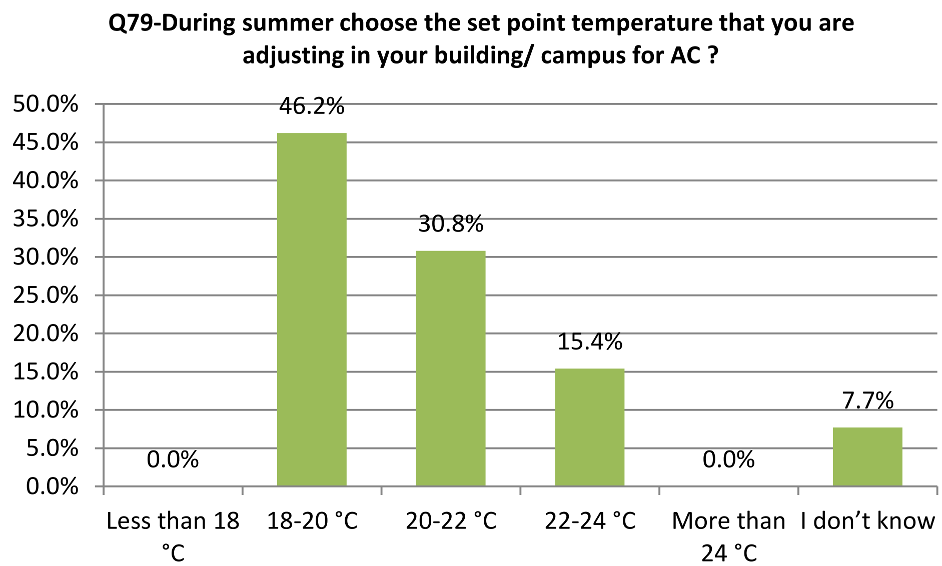

Figure 92.AC set point during summer –Electrical Engineers answer

90% of the organizations have an automatic switch for the AC, see table 57. 5:00am or 6:00am are the usual times for switching on ACs in buildings, 20% of buildings switch on at 5:00am and 50% at 6:00am.

10 pm is the most common time for switching off ACs, see table 58. The majority of respondents (90%) does not switch off or shut down ACs one hour before closing the building in order to save energy, see figure 96.

Table 57.Automatic switch on /off for the AC

Do you have an automatic switch on /off for the AC?	
Answer Options	**Response Percent**
Yes	90.0%
No	10.0%
I don't know	0.0%

Table 58.Time for switching on the AC

What is the time for switching on the AC in your building /campus?	
Answer Options	**Response Percent**
Before 5:00 AM	0.0%
5:00 AM	20.0%
6:00 AM	50.0%
7:00 AM	0.0%
After 7:00 AM	0.0%
I don't know	30.0%

Table 59.Time for switching off the AC

Q65-What is the time for switching off the AC in your building /campus?	
Answer Options	**Response Percent**
Before 7:00 PM	10.0%
8:00 PM	10.0%
9:00 PM	10.0%
10:00 PM	30.0%
After 10:00 PM	10.0%
I don't know	30.0%

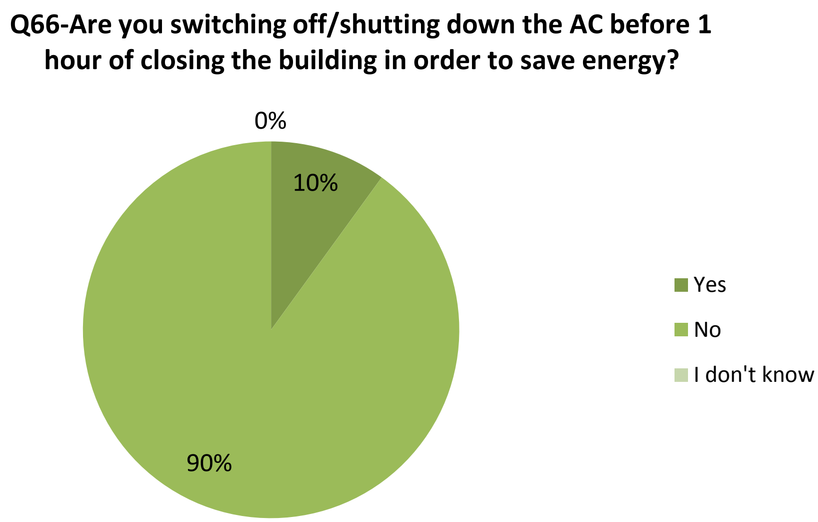

Figure 93. Switching off the AC an hour before closing the building

Table 60.Main reasons for high energy consumption

What are the main reasons for high energy consumption in your opinion?	
Answer Options	**Response Count**
Long operation hours Low AC set point	5

Applying a preventive maintenance plan is the most common practice and method implemented by participants' accounts in order to save energy consumption. After that two practices are counted which are: following building occupancy schedule and calibrating meters with the manufacturer's recommendation. In third place comes making benchmarks against similar structures, table 61 illustrates this question and answers.

Table 61.practices / technologies implemented in order to reduce energy consumption

Q69-How regularly you are checking and or inspecting the following (as a preventative maintenance plan)							
Answer Options	**weekly**	**Monthly**	**Quarterly (each 4 months)**	**Half year**	**annually**	**As manufacturers recommendations**	**Response Count**
Chilled Water Pump	2	2	3	2	2	5	10
Pressurization Unit	0	5	3	2	3	5	10
Air Handling Unit	1	4	4	2	3	5	10
Fan Coil Unit	1	3	4	2	3	5	10

Pressurization units are usually checked monthly, if not then they are checked quarter-annually and if not any of them then at least annually. Conversely, air handling units are checked monthly and quarter annually as well as all other items such as: fan cooling units, York water (cooled centrifugal chillers), cooling towers, primary chilled water pumps and York air (cooled reciprocating chillers).

Water pumps are checked as per the manufacturer's recommendation 50 percent of the time – in the case of the participants this happens monthly, quarter annually and annually with equal percentage shares of 20 percent by the participants' companies, table 62 and figure 97 illustrate preventative maintenance plan for HVAC.

Table 62.Preventative maintenance plan for HVAC

Q68-Please select the practices / technologies that you are implementing in order to monitor and reduce the energy consumption	
Answer Options	**Response Percent**
Following building occupancy schedule	60.0%
Applying a preventive maintenance plan	90.0%
Calibrating meters with the manufacturer's recommendations	60.0%
Doing Benchmark against Both Similar Buildings and Historical Data in order to monitor energy consumption	30.0%
None of the above	0.0%
Other (please specify)	10.0%

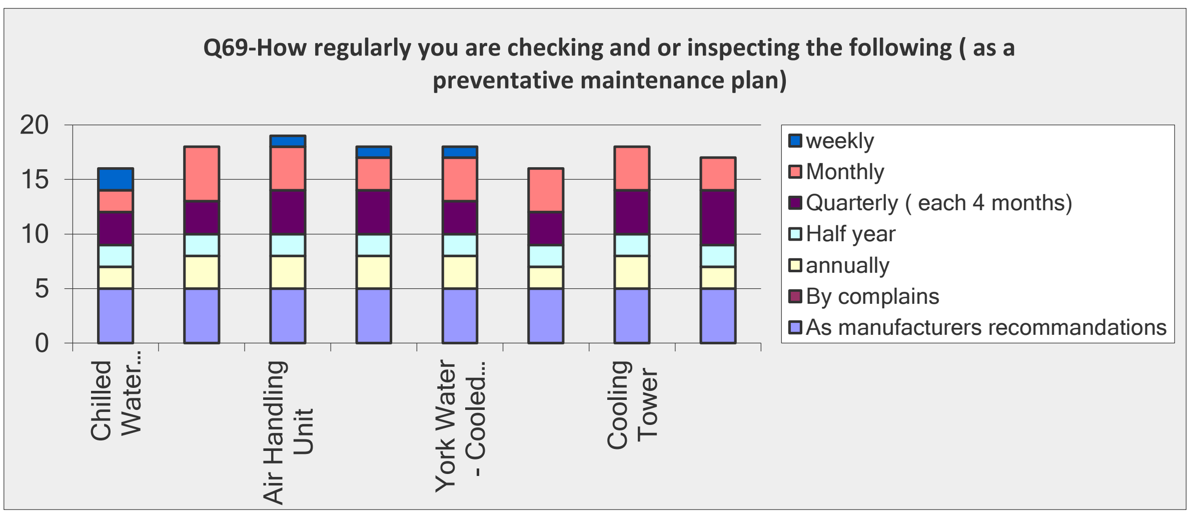

Figure 94. Preventative maintenance plan by HVAC department

Carpentry services department

Carpets with low emissions of volatile organic compounds and paints free of VOC coating are used in order to save the environment and enhance indoor air quality see table 63 to check the percentage for each practice. All equipment is mostly checked as per the recommendation of the manufacturer according to half of the participants. As a preventive maintenance plan roof membrane, wall painting, wall brick cracks and tiles are checked mostly by companies; while roof tops and roof-to-wall connections are checked usually half yearly and sanitary sewer connections are checked both weekly and annually.

Table 63.Practices implemented to reduce energy consumption by Carpentry services department

Q71-In order to save the environment and to enhance the indoor air quality what are the practices that are implemented in your building /campus? (Select all applicable)		
Answer Options	**Response Percent**	**Response Count**
Carpets with low emissions of volatile organic compound	42.9%	3
Paints and coatings wet-applied are VOC free	57.1%	4
None of the above	28.6%	2
Other (please specify)	14.3%	1

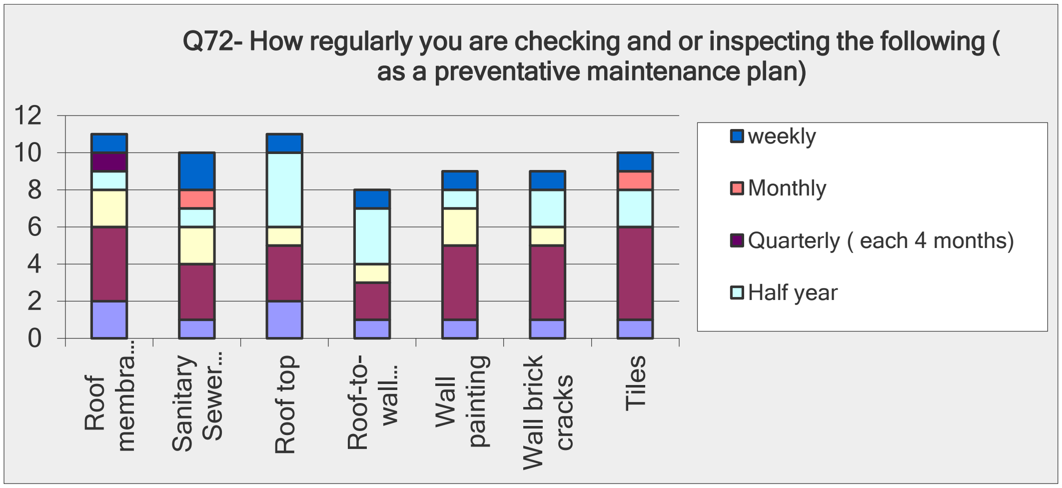

Figure 95.Preventive maintenance plan by Carpentry services department

Electricity Department

About 85 % of the participants said that they don't have solar panels to generate electricity. 60 % of those that said this showed that they are planning to have solar panels installed see figure 99.

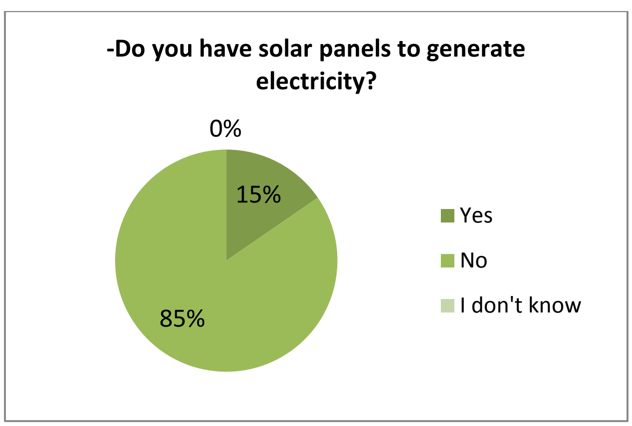

Figure 96.Percentage of solar panels to generate electricity

92% of participants stated that their buildings or campuses had a separate electric energy meter. More than a quarter had sub meters for different energy consumption in their buildings, including light and HVAC meters.

Table 64.Electricity meter for each building separately.

-Do you have electricity meter for each building separately in your campus?	
Answer Options	**Response Percent**
Yes	92%
No	8%
I don't know	0.0%

Table 65.sub meters for different energy consumption in your building

- Do you have sub meters for different energy consumption in your building?	
`	**Response Percent**
Yes	23%
No	69%
I don't know	8%

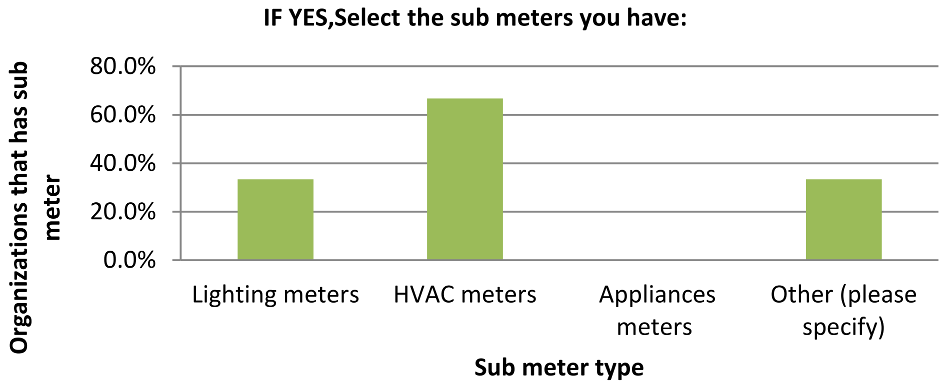

Figure 97. The type of electricity sub meters avaliable

Various practices are used and implemented to reduce electricity consumption. This includes implementing a preventive maintenance plan, using LED lights to reduce energy consumption, recording electricity meters and using light sensors. Table 66 shows the currently used and implemented practices in percentages.

Table 66.Practices used to reduce electricity consumption

Q85-Please select the practices / technologies that you are implementing in order to monitor and reduce the electricity consumption	
Answer Options	**Response Percent**
Implementing energy audit plan	15.4%
Using LED lights to reduce energy consumption	61.5%
Using Lighting sensors	53.8%
Recording electricity meters	61.5%
Implementing preventive maintenance plan	76.9%
None of the above	15.4%
Other (please specify)	0.0%

As a preventive maintenance plan all of the following are checked usually monthly as per the manufacturer's recommendation, for instance: Incoming circuit breakers, capacitor banks, bus couplers, metering and protection devices as well as main and sub main distribution boards (refer to stacked bar chart figure 101).

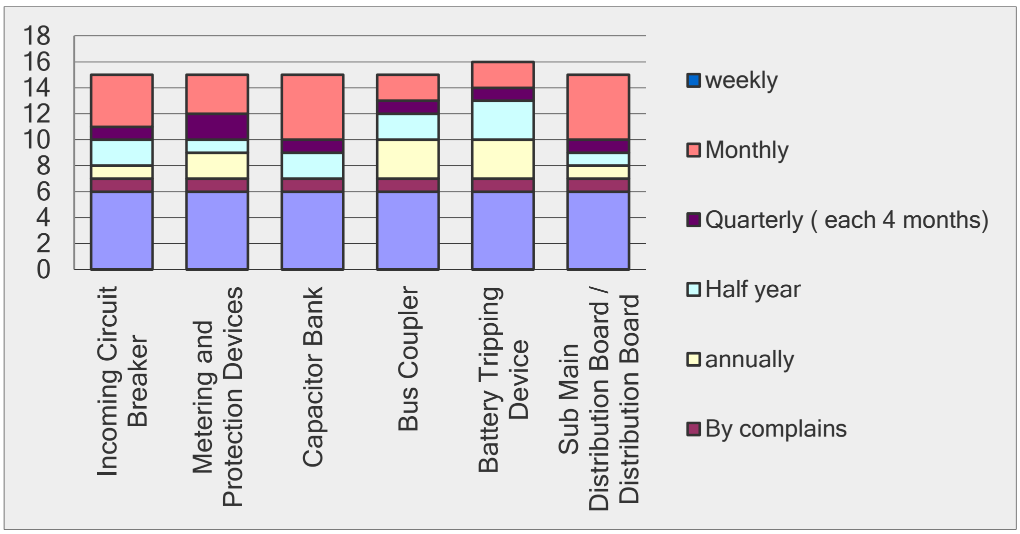

Figure 98.Preventive maintenance plan for electricity

It was discovered that none of the participants are implementing the RUES policy at the moment. One participant answered 'yes' to the question on whether or not some items are recycled, they said that one item is recycled which is water and one item is reused which is paper .

Summary of survey and general Findings

Awareness, knowledge and accreditations

The majority of participants recognize the importance of sustainability and SUS FM.A healthy percentage of Design/ construction participants received sustainability training from their organizations and some had green accreditations. While less of the FM personnel had green accreditation and the majority didn't receive any training from their FM organizations. Although the number of FM respondents was 62 and the non-FM (respondent was 43, they had assigned a similar number of Green accreditations.

All of these findings and results tell us that design / construction organizations are more conscious about the importance of sustainability than FM organizations.

FM involvement from early stages of the project

Both FM and non-FM personnel consider that the FM involvement is limited, however they are both adamant to focus on the fact that FM has to become involved from the early stages of design.

Strategies, plans and practices

The majority of answers reflect that strategies and plans for most organizations are still at the beginning stages. There are some SUS practices that are implemented in a good way and many other practices that don't exist. The best implemented practice by more than 94% in FM is following a preventive maintenance plan. This practice is assisting sustainability in terms of preserving equipment, as a result reducing energy consumption.

So many practices could be implemented and enhanced in FM.

Operation by FM

The set points for HVAC system are low, in most buildings they are between 18-22C, and this is raising energy consumption.

The operation time is long, it starts from 5:00AM - 7:00AM and ends 8:00PM -10:00PM

With very inconsistent occupancy patterns that drops to half after 2:30PM and to less than quarter after4:00PM.

Campuses are currently using mainly chillers and district cooling units especially for their new buildings.

Although DX- HVAC systems are consuming much more electricity than districts, they are still used on campuses and buildings.

Chapter 6: Conclusion and Recommendations

This thesis started with an extensive review of current academic literature now complete in this chapter as presented with a conclusion and recommendation. This section also provides the contribution of research to the diverse subject of sustainability in the field of facility management. Moreover, the chapter includes few recommendations on practices to be implemented in order to achieve sustainability.

Conclusion

FM is a growing service industry for all types of buildings around the world. FM is the responsible sector for operating buildings and this gives FM the importance of contributing to sustainability in terms of conserving energy. In view of the above, the effective sustainability practices in facility management become a key player in the success of any sustainability endeavor aiming to ensure a sustainable building life cycle. Robertson and Jones (2004)

The main objectives off this research were as follows:

- Investigate the nature of the FM industry in Qatar with a more focus on the educational sector.
- Assess the implementation of sustainability practices in FM.
- Analyze the energy consumption in education campuses in order to investigate the actual implementation of sustainability practices, moreover comparing certified buildings with non-certified buildings to insure that certified buildings are consuming less energy and to put them as model for the non-certified buildings.

All the objectives of this study were fulfilled except the goal of comparing a certified building with non-certified buildings since the data for certified buildings was neither available nor accessible in the researcher’s hands, although the researcher putting great effort in collecting such data.

As mentioned, all of the objectives were achieved as the interview and survey scanned the SUS FM industry in Qatar and investigated all factors that would affect SUS FM - those factors are summarized in the following points, as a result of the survey questionnaire and the literature review.

Factors that would affect sustainability in FM :

1. Experience of the FM personnel: this is because having sufficient amounts of work experience in the same building would better contribute to achieving sustainability. Staff that understands sustainability practices also has a better understanding of building operations; without sufficient experience at the same building, in-depth knowledge of managing the building goes missing.
2. Volume of buildings and how to deal with large unneeded volumes to reduce electricity consumption.(Elmualim et al, 2009)
3. Knowledge and training of the FM team in the field of sustainability as this would facilitate the implementation of sustainability practices.
4. Having clear plans and strategies to implement SUS practices.(Elmualim et al, 2009),(Meng ,2013)

5. FM team involvement from early project stages in order to facilitate more efficient building operation as the FM team becomes more skilled in seeking better ways of operating the building. (Duffy ,2000)

Interviews were conducted with 20 key personnel in the field of FM to look into strategies and plans for sustainability in FM, the strategies and plans for most organizations are still in the beginning stages. The interview was followed by an online survey that was conducted by distributing questions among the professionals in the FM departments and construction fields in order to obtain feedback on the following points:

- Sustainability Awareness, knowledge and accreditations
- FM involvement from early stages of the project
- Sustainability strategies, plans and practices

The majority of survey respondents were intended to be from the educational campuses that were used as case studies, those campuses included: Qatar University, Qatar foundation and Aspire campus. It was essential to have participants from these campuses in order to integrate their answers with the energy analysis stage which had investigated the consumption.

The results of the survey showed a complete convergence with interview results, and this reflects the integrity in opinions between managers that were interviewed and engineers who answered the questionnaire.

The results of the survey showed that the majority of FM departments recognize the importance of sustainability in FM. A healthy percentage of Design/ construction participants received sustainability training from their organizations and some had green accreditations. However fewer of the FM personnel had green accreditation and the majority didn’t receive any training from their FM organizations. All of these findings and results tell us that design / construction organizations are more conscious about the importance of sustainability than FM organizations. This also highlights the noted point of buildings having design and construction but lacking a sustainable building operation.

In all three campuses the FM team lacks extensive experience of employment at the same organization and this is considered as one main obstacle to achieving sustainability.

The involvement of the FM team from early project stages is limited; the construction/design team and the FM team are both welcoming to the idea that FM has to become involved from the early stages of design.

Barriers to implementing sustainability practices vary between the different parties that are responsible for the building, however a lack of culture of sustainability, and also lack of training and coordination are considered to be the most important barriers.

There are some SUS practices that are implemented in a good way and most of the practices that were investigated are not implemented in FM, examples of practices that are not adopted by FM:

- Switching off the AC one hour before the closing time of the building.
- Scheduling the building HVAC according to the occupant numbers; the FM schedule is considered for the maximum number of occupants per day, not the number of occupants that actually occurred..

The best implemented practice by more than 94% in FM is following a preventive maintenance plan. This practice is assisting sustainability in terms of preserving equipment, with the result of reducing energy consumption.

The most important fact which should be noted here is that the FM departments are keeping low AC temperatures inside buildings as the thermostat set point is between 18-20 degrees, as a result of this is higher energy consumption and decreased users' comfort is found. Campuses are currently using mainly districts cooling systems especially for their new buildings and air handling units (AHU) units are used in old buildings. Although DX-HVAC systems are consuming much more electricity than districts, they are still used on campuses and in buildings.

The energy analysis stage was investigated secondly in this research in order to ascertain whether sustainability practices were implemented or not, by investigating the actual amount of energy consumed.

Analyzing the energy consumption for the 10 buildings that were taken as case studies was essential to prove that applying sustainability practices is limited as resulted from the questionnaire results. The energy analysis was done by using several metrics which are: EUI, consumption / occupant (co/oc) and benchmarking the total consumption through years of operation.

The EUI for most of the buildings (8 buildings) is a good indication of energy consumption performance, as 8 buildings scored EUIs less than the ENERGY STAR standard. Although good EUI values were scored by most buildings on different campuses in Qatar, this does not reflect the real energy consumption performance. Consequently, there is a need to investigate energy consumption per occupant. As an additional step, this consumption was calculated based on the number of occupants, not building floor area. Benchmarking with foreign universities shows that Qatari campuses consume 1.5 to 2 times more than foreign campuses/occupants on campus.

This highlights that the number of occupants is not taken into account while operating Qatari campuses, moreover Qatari campuses are being operated at the same way of other broad campuses that had more students raised to 2-4 times more than Qatari campuses.

Although the heat load is much more in broad campuses according to the bigger amount of occupants compared to Qatari campuses; the energy consumption in Qatari campuses was more per occupant. This resulted in the fact that FM departments in Qatari education campuses are not scheduling the HVAC operation according to number of occupants, which needs to be investigated and implemented in future.

What needs to be taken into account as well is that consumption has increased throughout the years for all buildings, and as a result, EUI is increasing as well, but consumption per occupant is inversely decreasing. Hence, in operating the building it is a possibility that energy consumption could be evaluated based solely on the EUI value, irrespective of other parameters that impact energy consumption. Thus, considering the building function, number of occupants, number of labs and the type of HVAC are important to evaluate the energy consumption; this would require a planned energy monitor.

Hundreds of statistics in the future show an increase in heat loads due to the increase in number of occupants, this need to be investigated by serious plans to reduce energy consumption.

Research limitations

In any research there are certain limitations that could influence the study. In this research the main limitations are explained in the following points:

1- The availability of data about sustainability in facility management in Qatar was very limited Since no previous researches were conducted in Qatar in this field. If there were some available data then the researcher would go with deeper study to investigate more advanced issues in FM such as the use of BIM and its importance to sustainability. Moreover the researcher had spent the research time in collecting the basic data and there was no spare time to do modeling in order to simulate energy consumption to put it in comparison with the collected data.

2- Difficulties to contact participants and organizations. Moreover there were difficulties in collecting the required data for energy consumption, this obstacle had increased when the researcher asked for green certified buildings' data, which had affected the objectives of the study and prevent comparing the certified buildings with non-certified ones.

Recommendations

Thorough review of the academic literature has resulted in many suggestions relaying to sustainability practices. The survey that developed as part of this research asked the respondents to provide their feedback for implementing those practices. These practices are shown in Appendix E.

In addition to the suggested practices retrieved from the literature review, other suggestions are summarized below out of this research findings that were concluded from this study methods:

1. It is important to ensure proper involvement of FM teams from the design phase, furthermore coordination among the design/ construction team and the FM team has to exist depending on the phase of the project and other characteristics, since the development of FM involvement ensures better understanding of the project and easier operation of the building.
2. As some buildings have large volumes and this raises the electricity consumption due to the AC load, parts of the building could be modified to minimize the volume , this could be achieved by:
   - Reducing the height of the ceilings by erecting suspended panels as an additional ceiling in order to reduce the volume and therefore attain the well needed cooled air.
   - Reducing the area of the unneeded spaces by flexible severance.

- Scheduling the building operation according to the needed spaces and the number of occupants. A coordination must exist here between colleges and FM departments.
- FM has to monitor building occupancy and to have updated reports for the used and unused spaces in order to deal with the unused spaces by reducing the operation for them.

Figures 102, 103 and 104 recalls research objectives, research findings and suggest recommendations for the case studied buildings based on research objectives and findings. On the last step it gives recommendations for future researches keeping on mind all the data collected and analyzed.

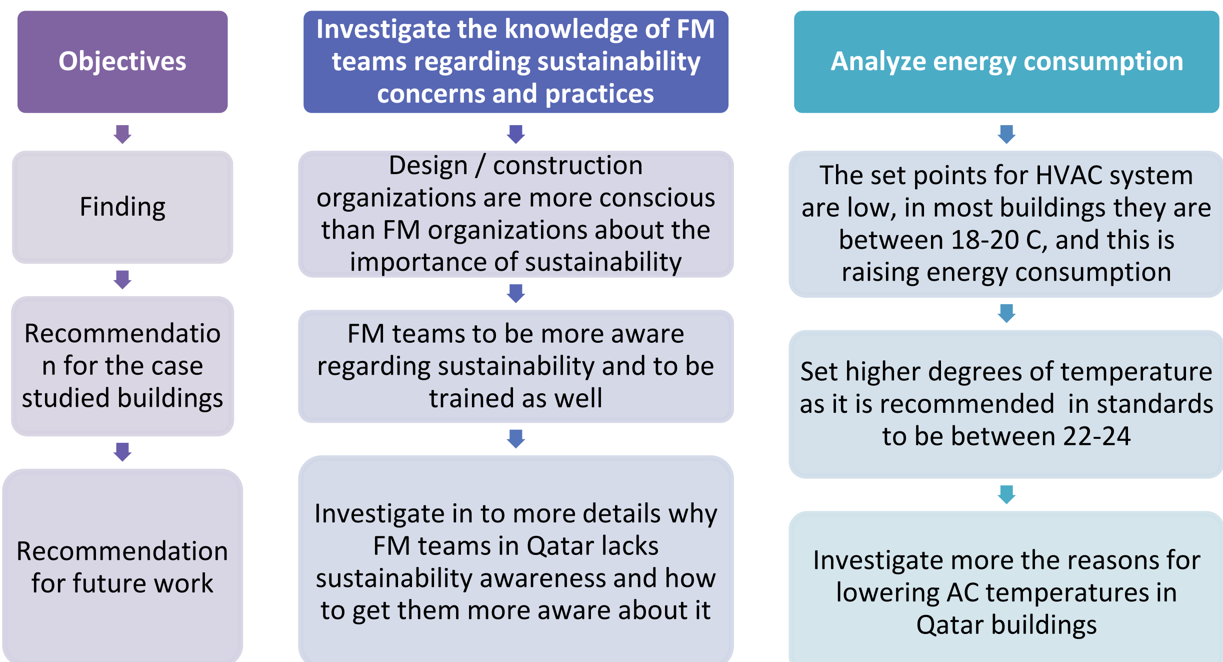

Figure 99: Recommendations based on research objectives and findings

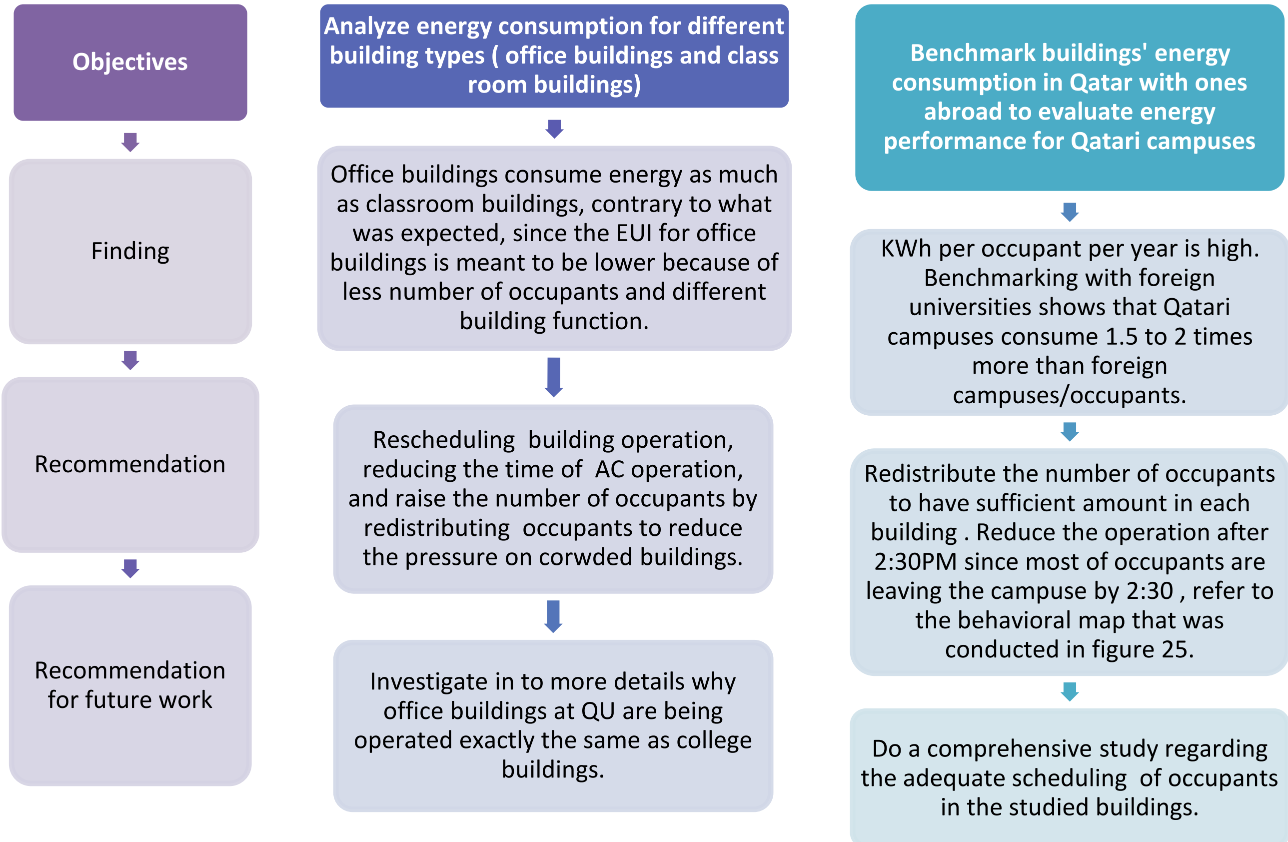

Figure 100.Recommendations based on research objectives and findings

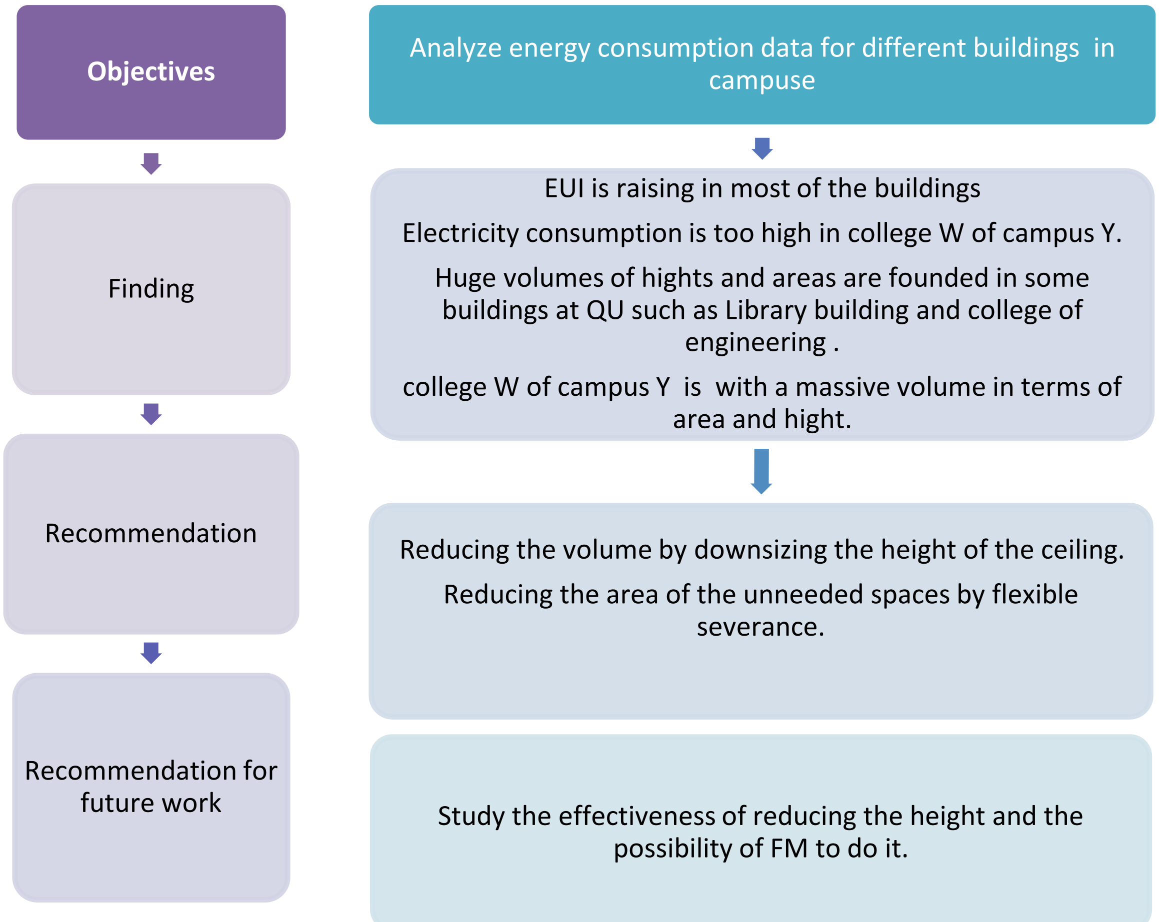

Figure 101. Recommendations based on research objectives and findings

Directions for Future research

The Sustainable Building research community has put in a lot of effort to understand how a building could be designed and constructed in a sustainable way, yet it had been found that there is a gap in the available academic literature in how to operate the building sustainably. Therefore the field of SUS FM needs to have more investigations on this issue. This paper summarizes future work that could be conducted out of this research in the following points:

- Future research could put one specific building under investigation and monitoring by implementing sustainable practices through one year and then compare the energy consumption for this monitored year with the historical data of energy consumption to measure the effectiveness of sustainability practices in achieving energy conservation and therefore reduce consumption.
- Future researches could investigate into more details the factors that are effecting sustainability in FM in Qatar, those factors were discussed previously such as: the relation between FM personal experience and implementing SUS practices.
- Conduct Building modeling to simulate energy consumption in order to compare the actual consumption with the modeled ones. Factors such as operation time to be considered as parameters throughout simulation to optimize practices and operation time in accordance with energy consumption.

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Appendix A: survey questions from literature review

- **<u>Paper 1: For</u>** facility managers. This research aims to answer the questions concerning. The interviews are carried out face-to-face or through telephone. Each interview lasts around an hour.

6. Is early FM involvement in design has significantly increased in today's practice?
7. What are the benefits from early FM involvement?
8. What types of projects are more suitable for early FM involvement?
9. What problems may occur if FM specialists are not involved in design?
10. What are still the barriers to early FM involvement?
11. How to encourage the wide?

- **<u>Paper 2 :</u>** For facility managers (and Engineers who are working in FM) . It was mixed between open ended questions and close ended questions

8. **'What does sustainability mean to you and how might you achieve it?'**

9. **'Is making your organization more sustainable a key objective for you within the next 12 months?',** with the answer options given as 'yes' or 'no'.

10. **'How might you achieve this?'**

11. **'Which of the following options most clearly resembles your involvement with FM?'** The options given for this question were: 'in-house FM', 'FM service provider', 'product supplier' and 'other (please specify)'.

12. **Does sustainability feature as an objective within your organization's corporate plan?**

13. **'Was sustainability reported upon within your organization last annual report?'**

14. **My organization find clearer, practical tools, information and industry best practice useful in the following areas'.** The respondents were given 17 areas identified in the pilot questionnaire and workshops with five options in each category where the respondents can choose from 'strongly agree', 'agree', 'don't know', 'disagree' and 'strongly disagree'. The second part was an open ended box where the respondents were posed with the question: 'In addition to the above. I/my organization believe the following should also be included'.

15. **Question 8 was to find out whether the respondents would be interested in attending workshops** and whether their organization could provide case study material as part of the development of the knowledge portal.

<u>Paper 3: (Engineers and Facility managers) by interviews</u>

1. How effective is your organization at implementing and managing its Sustainability Policy? (e.g. ensuring accountability, enabling feedback, making timely adjustments, and in promoting change)

2. In your opinion, how significant are the following influences in driving the implementation of sustainable practices in your organization?

3. In your opinion, how significant are the following influences in preventing your organization effectively managing its sustainability responsibilities?

<u>Paper 4</u>

1. Are you engaging in non-FM related conversations with your business units or key stakeholders?

2. Is the data you analyze building related, people related or both?

3. Do you create metrics that directly correlate with and contribute to specific balance sheet line items?

5. What are the backgrounds/ undergraduate degrees of your younger FM teams?

6. How often are you brought in to discuss workplace transformation needs from idea inception?

7. What, if any, key corporate initiatives are you engaged in that also routinely include your counterparts in IT, HR or accounting? Are you regularly collaborating with these counterparts in those projects?

Paper 5

		Strongly Agree	Agree	Disagree	Strongly Disagree	Don't Know or N/A
1. STRATEGIC PLANNING						
F1	The institution is formulating business objectives in a strategic plan.	O	O	O	O	☐
F2	Long/Medium Range Facility Plans are fully synchronized with the institutional strategic pan.	O	O	O	O	☐
F3	Organizational Strategic Planning is linked to a periodical planning cycle.	O	O	O	O	☐
F4	The organization is tracking performance metrics related to defined strategic business objectives.	O	O	O	O	☐
F5	It is understood which office is responsible for the performance of the identified metrics.	O	O	O	O	☐

2. FACILITIES & REAL ESTATE PORTFOLIO MANAGEMENT						
Requirements for New Facilities and Infrastructure						
F6	There is a formal process connecting the organization's strategic plan with other operational plans	O	O	O	O	☐
F7	Requirements for space and infrastructure are forecasted.	O	O	O	O	☐
Condition and Utilization of existing Facilities and Infrastructure						
F8	The organization invests into the renewal of existing assets on an ongoing basis.	O	O	O	O	☐
F9	The level of investments in existing assets is based on metrics such as the Facility Condition Index (FCI) or a percentage of the replacement value.	O	O	O	O	☐

Gap Analysis / Project Identification

F10	It is well understood who is responsible to collect and manage capital project proposals	○ ○ ○ ○	□
F11	All capital project proposals are identified using uniform templates across the organization	○ ○ ○ ○	□
F12	Proposals for Capital Projects are entered into a central database.	○ ○ ○ ○	□

s

Table 2. Reported top ten sport facility ES challenges

Reported sport facility ES challenges	Mean	SD
Energy reduction	4.72	0.99
Water reduction	4.54	1.27
Easy environmental programming for client/customers	4.36	1.91
Education/training for staff and patrons	4.27	1.45
Sourcing for environmentally friendly products	4.18	1.30
Waste reduction	4.18	1.19
Tools to measure energy savings	4.09	2.54
Effective personnel for design & implementation for environmental systems	4.09	2.18
Patron apathy toward recycling	4.00	1.80
Ensuring compliance	3.90	1.86

Table 3. Top ten ES sport facility trends most likely to happen by 2015

Reported top ten sport facility ES trends	Mean	SD
Use of light sensors as a means to reduce electricity use	4.54	0.99
More green purchase and awareness	4.45	1.27
Plumbing fixtures retrofit with water saving devices	4.45	1.91
Advanced use of building automation systems (BAS)	4.36	1.45
Better ways to monitor energy usage	4.36	1.30
LED lighting use	4.36	1.19
To better educate people on initiatives so they understand how to get on board (including staff training in environmental awareness)	4.18	2.54
Replacement of some necessary physical plant equipment with more energy efficient models	4.18	2.18
30% reduction in utilities	3.90	1.80
Younger, more environmentally friendly staff and management coming on board to make an impact on decision making	3.80	1.86

Appendix B :Contains the Survey – Questionnaire that was conducted for FM personal and non FM personal

Sustainability in facility management

1. Sustainability in facility management (survey - Questionnaire)

University of Qatar
College of Engineering
Engineering Management Master Program

Sustainable buildings had become a major issue in building construction today. Those buildings take into count creating comfortable and serviceable natural life. Sustainable buildings use key resources like energy, water, materials, and land more efficiently than buildings that are just built to
code. With more natural light and better air quality, sustainable buildings typically contribute to
improve employee and student health, comfort, and productivity
Since sustainability is an emotive topic nowadays because it has great objectives it should be adopted not only during the design and construction of the building but it has to continue during
the operation of the building.

Facility management is a profession that encompasses multiple disciplines to ensure functionality of the built environment by integrating people, place, process and technology. Facility management offers hard and soft functions in the building such as operation and maintenance of electricity services, HVAC services, waste management services, carpentry services, cleaning services and many others.Therefore facility management departments and functions have this responsibility of continuing the sustainable practices during the life cycle of buildings.

We are conducting this research in order to study the various practices that are taking place in Qatar to support sustainability moreover we aim to survey the knowledge of sustainability and sustainability in facility management.

All information, including all results and personal information from participating individuals will be kept strictly confidential and be used only for research purposes ONLY.

We thank you for your cooperation and your willingness to contribute to an initiative that will benefit Qatar.

ShorookAbdoh
Email: 200556054@qu.edu.qa

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ShorookAbdoh
Email: 200556054@qu.edu.qa

Thank you for participating in our survey. Your feedback is important.

Sustainability in facility management

2. General information

* 1. Address

Company

2. Address(optional)

Name

Email Address

Phone Number

* 3. Please select your degree Back ground:

- Architecture /Architecture Engineering
- Civil Engineering
- Electrical Engineering
- Mechanical Engineering
- Facility Technician/ Mechanic
- Other (please specify)

* 4. What is the highest level of education you have completed?

* 5. Years of experience

- 1-3
- 3-5
- 5-10
- 10-15
- More than 15

* 6. Years of experience in current Company

- 1-3
- 3-5
- 5-10
- 10-15
- More than 15

* 7. Years of experience in sustainability

- No experience
- 1-3
- 3-5
- 5-10
- 10-15
- More than 15

* 8. Are you working on FM currently?

- Yes
- No

Sustainability in facility management

3. FM personal

* 9. According to your work in FM, is the project delivered from the contractor to the operation and maintenance team with enough information and plans?

- Yes, enough information is provided
- It’s difficult to recover and maintain the information when needed
- No enough information provided
- Part of information is given but Operation and Maintenance instructions and manual input is still required
- Didn’t reach to the stage of operation and maintenance, I don’t know if I have enough information

* 10. Is there an involvement of FM team from the design phase?

- Yes
- No
- Limited involvement

* 11. What is the best stage in the project for the FM personal to be involved in?

- From the Design Phase
- During the construction Phase
- In both phases
- After project completion
- I don’t know
- Other (please specify)

* 12. Select the phase that you are involved in during current projects that you are working on:

- From the Design Phase
- During the construction Phase
- In both phases
- After project completion
- I don’t know
- Other (please specify)

* 13. Did you receive any training and /or workshops regarding sustainability in your current organization?

Yes No

* 14. Would you be interested in being trained in sustainability practices or in sustainability on Facility management for your work?

Yes No Somehow

* 15. In the near future do you expect sustainability practices/ policies to impact your job?

Yes No I don't know

16. How important do you believe Sustainability to be for the FM industry?

- Very important
- Important
- Neutral
- Very unimportant
- Unimportant

* 17. Is there a separate department in your organization for sustainability or energy and environment?

- Yes
- No
- We are planning to have one
- I don't know

* 18. Are there sustainability practices at your organization or is it recently implemented?

- We currently implement sustainability practices and have sustainability policy
- We have sustainability plans and policies but we are not yet implementing it
- In one year’s time we will implement sustainability practices
- In five years’ time we will implement sustainability practices
- No plans to implement sustainability practices
- N/A

* 19. Do you have annual sustainability report?

- Yes
- No
- I don't know

* 20. How would you rate your knowledge and skills in sustainability? (5 highest -1 lowest)

- 1
- 2
- 3
- 4
- 5

Sustainability in facility management

4. Green Accreditations

21. How many LEED buildings do you have in your campus or intended to have within 2 years?

- No LEED buildings
- 1
- 2-4
- 4-6
- I don't know
- Other (please specify)

* 22. DO you have any Green accreditation? please select the applicable ones:

- NO
- Yes, LEED GA
- Yes, LEED AP
- Yes , GSAS
- Other (please specify)

Sustainability in facility management

5. Sustainability knowledge

23. Rank the following aspects according to their importance in achieving sustainability on FM (considering 7 the highest and 1 the lowest)

- Energy efficiency
- Water efficiency
- Waste management
- Indoor Environment Quality
- Site Quality
- Material management
- Cultural aspects

24. What do you think are the main obstacles for implementing sustainability practices?

	Strongly Disagree	Disagree	Neutral	Agree	Strongly agree
Lack a culture of sustainability					
Government is not supporting sustainability practices					
Sustainability wasn't a strategic priority for this organization					
Facility management is not yet convinced with sustainability benefits					
Lack of Facility manager expertise					
Lack of training					
Owners and clients are not aware of sustainability					
High initial Cost					
No clear standardized tools and practices to be followed					
Lack of coordination					
Lack of best sustainability practices and case studies					

25. Rank the following in which sustainability Can benefit according to your understanding of sustainability (considering 9 the highest and 1 the lowest)

- Minimize usable consumption
- Minimize water consumption
- Minimize energy consumption
- Enhance resources utilization
- Iincrease users service and satisfaction
- Makes work more interesting
- Improve the overall understanding of the building
- Reducing trash and pollution
- Reduce degradation of environment

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Sustainability in facility management

6. Non FM personal

* 26. Select the phase that you are involved in during current projects that you are working on:

- From the Design Phase
- During the construction Phase
- In both phases
- After project completion
- I don't know
- Other (please specify)

* 27. Did you receive any training and /or workshops regarding sustainability in your current organization?

- Yes
- No

* 28. Would you be interested in being trained in sustainability practices or in sustainability?

- Yes
- No
- Somehow

* 29. In the near future do you expect sustainability practices/ policies to impact your job?

- Yes
- No
- I don't know

30. How important do you believe Sustainability to be for design and construction?

- Very important
- Important
- Neutral
- Very unimportant
- Unimportant

* 31. Is there a separate department in your organization for sustainability or energy and environment?

- Yes
- No
- We are planing to have one
- I don't know

* 32. Are there sustainability practices at your organization or is it recently implemented?

- We currently implement sustainability practices and have sustainability policy
- We have sustainability plans and policies but we are not yet implementing it
- In one year’s time we will implement sustainability practices
- In five years’ time we will implement sustainability practices
- No plans to implement sustainability practices
- N/A

* 33. Do you have annual sustainability report in your organization?

Yes No I don't know

* 34. Do y you think that buildings are over sized (bigger than needed) in Qatar?

- Yes , all buildings are over sized
- Yes, most of the buildings are over sized
- Yes, some buildings are over sized
- No, buildings are not over sized and this size is needed

* 35. Do you think that the height is more than needed, as in some buildings it’s over than 4.5m?

Yes No I don't know

* 36. Do you think that the extra height can affect energy consumption in terms of using more AC?

Yes No I don't know

37. How many LEED buildings did you design or construct by your organization/company?

- No LEED buildings
- 1
- 2-4
- 4-6
- I don't know
- Other (please specify)

* 38. DO you have any Green accreditation? please select the applicable ones:

- NO
- Yes, LEED GA
- Yes, LEED AP
- Yes , GSAS
- Other (please specify)

39. What do you think are the main obstacles for implementing sustainability practices?

	Strongly Disagree	Disagree	Neutral	Agree	Strongly agree
Lack a culture of sustainability					
Government is not supporting sustainability practices					
Lack of training					
Owners and clients are not aware of sustainability					
High initial Cost					
No clear standardized tools and practices to be followed					
Lack of coordination					
Lack of best sustainability practices and case studies					

Sustainability in facility management

7. Over sized buildings and energy consumption

* 40. Do y you think that buildings are over sized (bigger than needed) in Qatar?

- Yes , all buildings are over sized
- Yes, most of the buildings are over sized
- Yes, some buildings are over sized
- No, buildings are not over sized and this size is needed

* 41. Do you think that the extra height can affect energy consumption in terms of using more AC?

- Yes
- No
- I don't know

* 42. Do you think that the height is more than needed, as in some buildings it’s over than 4.5m?

- Yes
- No
- I don't know

Sustainability in facility management

8. Maintenance and sustainability

43. What types of maintenance you are applying in your building/campus?(select all applicable)

- [ ] Reactive maintenance
- [ ] Corrective maintenance
- [ ] Preventive (or scheduled) maintenance
- [ ] Predictive maintenance

44. Are you applying preventive maintenance plan?

○ Yes ○ No ○ I don't know

45. Rate the importance of applying preventive maintenance plan in order to sever sustainability?

○ Very important

○ Important

○ Neutral

○ Very unimportant

○ Unimportant

Sustainability in facility management

9. FM departments

* 46. Please select the department in which you are working in (if working on FM)

- Carpentry services
- Cleaning services
- HVAC services
- Waste management services
- Plumbing services
- Civil work services
- Electrical services
- Other (please specify)

Sustainability in facility management

10. HVAC services

47. What is the HVAC system/s that is used in your building / campus? (select all applicable)

- Water cooled chiller
- Packaged unit
- Air cooled chiller
- Split unit
- VRF-VRV
- Window unit
- Other (please specify)

* 48. Select the technology that is applied in your HVAC in order to reduce energy consumption and meet thermal comfort:(select all applicable)

- Heat recovery
- Economizer (double mixing box)
- CO2 sensors
- None of the above
- Other (please specify)

* 49. IF you don't have any of what mentioned above, are you planning to install?

Yes No I don't know

* 50. Did you change any HVAC systems in your building or other buildings in campus?

Yes No I don't know

51. IF YES from which system to which?

52. Are you considering a feasibility study to be done before doing any retrofits or upgrades for HVAC?

Yes No I don't know

53. Do you have sub metering for HVAC to record the energy consumption?

Yes ,In all buildings

Yes, In some buildings

No, We don’t have it in any building

I don't know

* 54. DO you think that the size of your building/ campus affecting energy consumption?

Yes No

* 55. Do you think that this size is more than required?

Yes this size is more than needed in all buildings

Yes this size is more than needed in some of the buildings

No this size is needed

* 56. Do you use chlorofluorocarbon (CFC)-based refrigerants in heating, ventilating, air-conditioning, and refrigeration (HVAC&R) systems?

Yes No I don't know

57. IF YES , are you planning to replace them?

Yes No I don't know

58. Are you considering a feasibility study (initial cost - pay back analysis) for any replacement / upgrade/conversion for the HVAC?

Yes No I don't know

59. During summer choose the set point temperature that you are adjusting in your building/ campus for AC ?

- Less than 18 °C
- 18-20 °C
- 20-22 °C
- 22-24 °C
- More than 24 °C
- I don’t know

60. During winter choose the set point temperature that you are adjusting in your building/ campus for HVAC ?

- Less than 18 °C
- 18-20 °C
- 20-22 °C
- 22-24 °C
- More than 24 °C
- I don’t know

* 61. Do you have an automatic switch on /off for the AC?

- Yes
- No
- I don't know

* 62. What is the time for switching on the AC in your building /campus?

- Before 5:00 AM
- 5:00 AM
- 6:00 AM
- 7:00 AM
- After 7:00 AM
- I don't know

* 63. What is the time for switching off the AC in your building /campus?

- Before 7:00 PM
- 8:00 PM
- 9:00 PM
- 10:00 PM
- After 10:00 PM
- I don't know

* 64. Are you switching off/shutting down the AC before 1 hour of closing the building in order to save energy?

- Yes
- No
- I don't know

Other (please specify)

65. What are the main reasons for high energy consumption in your opinion?

66. Please select the practices / technologies that you are implementing in order to monitor and reduce the energy consumption

- ☐ Following building occupancy schedule
- ☐ Applying a preventive maintenance plan
- ☐ Calibrating meters with the manufacturer's recommendations
- ☐ Doing Benchmark against Both Similar Buildings and Historical Data in order to monitor energy consumption
- ☐ None of the above
- ☐ Other (please specify)

67. How regularly you are checking and or inspecting the following (as a preventative maintenance plan)

	weekly	Monthly	Quarterly (each 4 months)	Half year	annually	As manufacturers recommandations	By complains
Chilled Water Pump	☐	☐	☐	☐	☐	☐	☐
Pressurization Unit	☐	☐	☐	☐	☐	☐	☐
Air Handling Unit	☐	☐	☐	☐	☐	☐	☐
Fan Coil Unit	☐	☐	☐	☐	☐	☐	☐
York Water - Cooled Centrifugal Chiller	☐	☐	☐	☐	☐	☐	☐
Primary Chilled Water Pump	☐	☐	☐	☐	☐	☐	☐
Cooling Tower	☐	☐	☐	☐	☐	☐	☐
York Air - Cooled Reciprocating Chiller	☐	☐	☐	☐	☐	☐	☐

68. If you would like to add comments and /or more data, please place it here.
Thanks for your response

Sustainability in facility management

11. Civil and carpentry services

69. In order to save the environment and to enhance the indoor air quality what are the practices that are implemented in your building /campus? (Select all applicable)

- ☐ Carpets with low emissions of volatile organic compound
- ☐ Paints and coatings wet-applied are VOC free
- ☐ None of the above
- ☐ Other (please specify)

70. How regularly you are checking and or inspecting the following (as a preventative maintenance plan)

	weekly	Monthly	Quarterly (each 4 months)	Half year	annually	By complains	As manufacturers recommandations
Roof membrane	☐	☐	☐	☐	☐	☐	☐
Sanitary Sewer Connections	☐	☐	☐	☐	☐	☐	☐
Roof top	☐	☐	☐	☐	☐	☐	☐
Roof-to-wall connection	☐	☐	☐	☐	☐	☐	☐
Wall painting	☐	☐	☐	☐	☐	☐	☐
Wall brick cracks	☐	☐	☐	☐	☐	☐	☐
Tiles	☐	☐	☐	☐	☐	☐	☐

71. If you would like to add comments and /or more data, please place it here.
Thanks for your response

Sustainability in facility management

12. Electrical services

72. Do you have solar panels to generate electricity?

○ Yes ○ No ○ I don't know

73. IF NO : Are you planning to have?

○ Yes ○ No ○ I don't know

74. Do you have electricity meter for each building separately in your campus?

○ Yes ○ No ○ I don't know

75. Do you have sub meters for different energy consumption in your building?

○ Yes ○ No ○ I don't know

76. IF YES, Select the sub meters you have:

☐ Lighting meters

☐ HVAC meters

☐ Appliances meters

☐ Other (please specify)

* 77. During summer choose the set point temperature that you are adjusting in your building/ campus for AC ?

○ Less than 18 °C ○ 18-20 °C ○ 20-22 °C ○ 22-24 °C ○ More than 24 °C ○ I don’t know

* 78. During winter choose the set point temperature that you are adjusting in your building/ campus for HVAC ?

- Less than 18 °C
- 18-20 °C
- 20-22 °C
- 22-24 °C
- More than 24 °C
- I don't know

* 79. Do you have an automatic switch on /off for the AC?

- Yes
- No
- I don't know

* 80. What is the time for switching on the AC in your building /campus?

- Before 5:00 AM
- 5:00 AM
- 6:00 AM
- 7:00 AM
- After 7:00 AM
- I don't know

* 81. What is the time for switching off /shutting down the AC in your building /campus?

- Before 7:00 PM
- 8:00 PM
- 9:00 PM
- 10:00 PM
- After 10:00 PM
- I don't know

* 82. Are you switching off/shutting down the AC before 1 hour of closing the building in order to save energy?

- Yes
- No
- I don't know

Other (please specify)

83. Please select the practices / technologies that you are implementing in order to monitor and reduce the electricity consumption

- [ ] Implementing energy audit plan
- [ ] Using LED lights to reduce energy consumption
- [ ] Using Lighting sensors
- [ ] Recording electricity meters
- [ ] Implementing preventive maintenance plan
- [ ] None of the above
- [ ] Other (please specify)

84. How regularly you are checking and or inspecting the following (as a preventative maintenance plan)

	weekly	Monthly	Quarterly (each 4 months)	Half year	annually	As manufacturers By complains recommandations	
Incoming Circuit Breaker	☐	☐	☐	☐	☐	☐	☐
Metering and Protection Devices	☐	☐	☐	☐	☐	☐	☐
Capacitor Bank	☐	☐	☐	☐	☐	☐	☐
Bus Coupler	☐	☐	☐	☐	☐	☐	☐
Battery Tripping Device	☐	☐	☐	☐	☐	☐	☐
Sub Main Distribution Board / Distribution Board	☐	☐	☐	☐	☐	☐	☐

85. If you would like to add comments and /or more data, please place it here.
Thanks for your response

Sustainability in facility management

13. Waste management and cleaning services

86. Are you implementing REUSE policy ?

◯ Yes ◯ No ◯ I don't know

87. IF YES, What types of items are reused?

- [ ] Water
- [ ] Paper
- [ ] Corrugated cardboard
- [ ] Glass
- [ ] Plastics
- [ ] Batteries
- [ ] Metals
- [ ] None of the above
- [ ] Other (please specify)

88. Are you implementing RECYCLE policy ?

◯ Yes ◯ No ◯ I don't know

89. IF YES, What types of items are recycled?

- [ ] Water
- [ ] Paper
- [ ] Corrugated cardboard
- [ ] Glass
- [ ] Plastics
- [ ] Batteries
- [ ] Metals
- [ ] None of the above
- [ ] Other (please specify)

90. Do you have storage for recyclable materials?

( ) Yes ( ) No ( ) I don't know

91. At what time the cleaning process take place in your building/campus?

( ) Early morning before working hours of employees started

( ) During working hours of employees

( ) After working hours of employees

Other (please specify)

92. Select the purchasing practices that are followed in your building /campus in order to reduce the waste: (Select all applicable)

- [ ] Extended use batteries (rechargeable ones)
- [ ] Toner cartridges for laser printers must be remanufactured
- [ ] Lights with free mercury
- [ ] None of the above
- [ ] Other (please specify)

93. In order to save the environment and to enhance the indoor air quality what are the practices that are implemented in your building /campus? (Select all applicable)

- [ ] Local sourcing of food and beverages, within (160 kilometers) of the site.
- [ ] Materials with low emissions of volatile organic compounds
- [ ] Paints and coatings wet-applied are VOC free
- [ ] None of the above
- [ ] Other (please specify)

94. In order to raise users awareness of reducing wastes what are the practices that are implemented in your building campus? (Select all applicable)

- [ ] Toilet tissues with sensors container
- [ ] Awareness signage in toilets to reduce tissues consumption
- [ ] Awareness signage in toilets to reduce water consumption
- [ ] Awareness signage in offices to reduce paper consumption
- [ ] Signage in offices to encourage paper reuse
- [ ] Limited number of papers assigned for each employee to be printed
- [ ] Signage in food service and cafeteria areas to reduce the food waste
- [ ] Food service employee training on reducing waste in food preparation and selecting menu options to reduce the potential for food waste
- [ ] None of the above
- [ ] Other (please specify)

95. If you would like to add comments and /or more data, please place it here.
Thanks for your response

Sustainability in facility management

14. Plumbing Services

96. Please select the consumption of toilet flushing(water closet) that is available in your building/campus.
gpf= Gallon per flush

- ◯ 1.6 gpf
- ◯ 1.6- 2 gpf
- ◯ 2- 2.2 gpf
- ◯ 2.2- 2.4 gpf
- ◯ More than 2.4
- ◯ Other (please specify)

97. How do you conduct leakage in your buildings/ campus? Select all applicable

- ☐ Observation
- ☐ Sub meters
- ☐ Complains of users
- ☐ Other (please specify)

98. Do you have sub meters for different appliances and fixtures in your building?

- ◯ Yes
- ◯ No
- ◯ I don't know
- ◯ Other (please specify)

99. IF YES, please select the sub meters you have :

- [ ] Indoor plumbing fixtures and fittings
- [ ] Cooling towers. Meter replacement water use of all cooling towers serving the facility
- [ ] Pools meters
- [ ] Domestic hot water meter
- [ ] Other (please specify)

100. Are you recording those meter readings?

- ( ) Yes
- ( ) No
- ( ) I don't know
- ( ) Other (please specify)

101. What is the method for recording?

- ( ) Manually
- ( ) Automated
- ( ) I don't know
- ( ) Other (please specify)

102. How regularly you are recording them?

- ( ) Weekly basis
- ( ) Monthly basis
- ( ) I don't know
- ( ) Other (please specify)

103. Did you conduct any replacement for fittings and fixtures in order to reduce water consumption?

- Yes
- No
- I don’t know
- Other (please specify)

104. IF YES ,Did you conduct a feasibility study for this replacement?

- Yes
- No
- I don’t know
- Other (please specify)

105. Do you think it is worth economically to do some fixtures replacement as this will reduce the water consumption?

- Yes
- No
- I don’t know
- Other (please specify)

106. Please select the practices / technologies that you are implementing in order to monitor and reduce the water consumption

- ☐ Faucets' sensors
- ☐ Half flushing tank
- ☐ Do awareness for users to not consume much water
- ☐ Implement a preventative maintenance plan
- ☐ The Meters are calibrated within the manufacturer's recommended interval
- ☐ Meter fixtures and fittings consumption and record meter data for one year to establish a water-use baseline
- ☐ Recycling grey water that is coming from faucets to go in to flushing tank
- ☐ Water recycling systems
- ☐ None of the above
- ☐ Other (please specify)

107. How regularly you are checking and or inspecting the following (as a preventative maintenance plan)

	weekly	Monthly	Quarterly (each 4 months)	Half year	annually	As manufacturers By complains recommandations	
Tanks Pumps	☐	☐	☐	☐	☐	☐	☐
Sanitary Sewer Connections	☐	☐	☐	☐	☐	☐	☐
Hot water tanks and circulating pumps	☐	☐	☐	☐	☐	☐	☐
Rain Drains	☐	☐	☐	☐	☐	☐	☐
Fixtures aerators	☐	☐	☐	☐	☐	☐	☐
Flushing valves	☐	☐	☐	☐	☐	☐	☐

108. If you would like to add comments and /or more data, please place it here.
Thanks for your response

Appendix C : List of LEED[3] certified buildings or registered to be certified in Qatar

Name of the project	Location	Type of LEED	Points	Level	Organization type	Project type
Confidential	Confidential	LEED-CS 2.0			Confidential	Commercial Office, Retail, Hotel/Resort
QF Education City-Male Campus RCC	Doha	LEED-NC 2.2	55	Platinum	Non-Profit Org.	Higher Education, Campus (corp/school), Community Dev.
QF Education City-Male Campus Res. Hall1	Doha	LEED-NC 2.2	56	Platinum	Non-Profit Org.	Multi-Unit Residence, Higher Education, Campus (corp/school)
QF Education City-Male Campus Res. Hall2	Doha	LEED-NC 2.2	56	Platinum	Non-Profit Org.	Multi-Unit Residence, Higher Education, Campus (corp/school)
QF Education City-Male Campus Apt.Bldg.1	Doha	LEED-NC 2.2	55	Platinum	Non-Profit Org.	Multi-Unit Residence, Higher Education, Campus (corp/school)
QF Education City-Male Campus Apt.Bldg.2	Doha	LEED-NC 2.2	55	Platinum	Non-Profit Org.	Multi-Unit Residence, Higher Education, Campus (corp/school)
QF Education City-Male Campus Apt.Bldg.3	Doha	LEED-NC 2.2	55	Platinum	Non-Profit Org.	Multi-Unit Residence, Higher Education, Campus (corp/school)
QF Education City-Female Campus RCC	Doha	LEED-NC 2.2	55	Platinum	Non-Profit Org.	Higher Education, Campus (corp/school), Community Dev.
QF Education City-FemaleCampus Res.Hall1	Doha	LEED-NC 2.2	57	Platinum	Non-Profit Org.	Multi-Unit Residence, Higher Education, Campus (corp/school)
QF Education City-FemaleCampus	Doha	LEED-NC 2.2	56	Platinum	Non-Profit Org.	Multi-Unit Residence, Higher Education, Campus (corp/school)

[3] Source : USGBC website

Res.Hall2						
QF Education City-Female CampusAptBldg1	Doha	LEED-NC 2.2	56	Platinum	Non-Profit Org.	Multi-Unit Residence, Higher Education, Campus (corp/school)
QF Education City-Female CampusAptBldg2	Doha	LEED-NC 2.2	55	Platinum	Non-Profit Org.	Multi-Unit Residence, Higher Education, Campus (corp/school)
QF Education City-Female CampusAptBldg3	Doha	LEED-NC 2.2	55	Platinum	Non-Profit Org.	Multi-Unit Residence, Higher Education, Campus (corp/school)
Confidential	Confidential	LEED-NC 2.2			Confidential	Higher Education
ecq-f12 taameer energy corner	doha	LEED-CS 2.0			Individual	Commercial Office, Retail
Confidential	Confidential	LEED-CS 2.0			Confidential	Commercial Office
Confidential	Confidential	LEED-NC 2.2			Confidential	Commercial Office
Energy City Qatar Headquarters Complex	Doha	LEED-CS 2.0			Profit Org.	Commercial Office
BRANCHES	Lusail	LEED-CS 2.0			Profit Org.	Commercial Office
Confidential	Confidential	LEED-NC 2.2	42	Gold	Confidential	Commercial Office, Assembly, Community Dev.
Confidential	Confidential	LEED-NC 2.2			Confidential	Multi-Unit Residence, Commercial Office, Retail, Hotel/Resort, Restaurant
Confidential	Confidential	LEED-NC 2.2			Confidential	Commercial Office, Retail, Restaurant
Confidential	Confidential	LEED-CS 2.0	47	Platinum	Confidential	Commercial Office
Confidential	Confidential	LEED-CS 2.0			Confidential	Commercial Office, Library, Community Dev.
Confidential	Confidential	LEED-CS 2.0	37	Gold	Confidential	Commercial Office, Multi-Unit Residence
Confidential	Confidential	LEED-CS 2.0			Confidential	Multi-Unit Residence, Commercial Office, Retail, Hotel/Resort, Restaurant
ECQ D-17 Qatar Finance House	Energy City	LEED-NC 2.2			Profit Org.	Commercial Office, Financial & Comm.
Confidential	Confidential	LEED-NC 2.2			Confidential	Other
Confidential	Confidential	LEED-CS 2.0			Confidential	Multi-Unit Residence, Commercial Office, Retail, Restaurant, Assembly
ECQ E-9 and E-10 Abdulghani Group	Energy City Qatar	LEED-NC 2.2			Profit Org.	Commercial Office

Al Ansary Office Building	Lusail	LEED-CS 2.0			Individual	Commercial Office
Confidential	Confidential	LEED-NC 2.2			Confidential	Higher Education
Confidential	Confidential	LEED-NC 2.2			Confidential	Multi-Unit Residence
B04 ECQ	Lusail	LEED-CS 2.0			Local Government	Commercial Office
Gaia	Doha	LEED-CS 2.0			Profit Org.	Commercial Office, Retail, Restaurant, Financial & Comm.
ECQ B-5 and B-6 Hadid& Partners	Lusail	LEED-NC 2.2			Profit Org.	Commercial Office
AL MARRUNA OFFICE BUILDING E-01	DOHA	LEED-NC 2.2			Profit Org.	Commercial Office, Financial & Comm.
Confidential	Confidential	LEED-NC 2.2			Confidential	Commercial Office, Retail, Restaurant, Financial & Comm.
AL GHANIM OFFICE BUILDING ECQ-D-19	DOHA	LEED-NC 2.2			Profit Org.	Commercial Office, Financial & Comm.
OLAYAN OFFICE COMPLEX	Lusail	LEED-CS 2.0			Profit Org.	Commercial Office
UNION	Lusail	LEED-CS 2.0			Profit Org.	Commercial Office
Confidential	Confidential	LEED-NC 2.2			Confidential	Higher Education
RasGas Headquarters Building	Doha	LEED-CI 2.0			Profit Org.	Commercial Office
FLAME 1	Lusail	LEED-CS 2.0			Profit Org.	Commercial Office
ALHASHEMI BUILDING	Lusail	LEED-CS 2.0			Individual	Commercial Office
FLAME 4	Lusail	LEED-CS 2.0			Profit Org.	Commercial Office
AWAAR	Lusail	LEED-CS 2.0			Profit Org.	Commercial Office
FLAME 2	Lusail	LEED-CS 2.0			Profit Org.	Commercial Office
FLAME 3	Lusail	LEED-CS 2.0			Profit Org.	Commercial Office
BARAKA	Lusail	LEED-CS 2.0			Profit Org.	Commercial Office
Confidential	Confidential	LEED-NC 2.2			Confidential	Other
MENA B-11 Project	Lusail	LEED-CS v2009				Commercial Office
Office Building for PETROTEC	Doha,Qatar	LEED-NC v2009				Commercial Office
Confidential	Confidential	LEED-CS v2009			Confidential	Office: Mixed-Use
Energy City Qatar Plots F09-F10	Lusail	LEED-CS v2009			Corporate: Publicly Traded	Office: Mixed-Use
Confidential	Confidential	LEED-CS	65	Gold	Confidential	Datacenter

		v2009				
Confidential	Confidential	LEED-CS v2009			Confidential	Office: Administrative/Professional
Confidential	Confidential	LEED-CS v2009	83	Platinum	Confidential	Datacenter
Confidential	Confidential	LEED-CS v2009			Confidential	Office: Other Office
RasGas Headquarters Building Project	Doha	LEED-CI v2009	67	Gold	Corporate: Privately Held	Office: Other Office
ALAQARIA DELTA CENTER	DOHA	LEED-CS v2009			Corporate: Privately Held	Office: Administrative/Professional
Qatar Academy At Al Khor	Doha	LEED FOR SCHOOLS v2009			Educational: K-12 School, Private	Core Learning Space: K-12, Elementary/Middle School
ECQ E02	DOHA	LEED-NC v2009			Corporate: Privately Held	Office: Administrative/Professional
ECQ E03	DOHA	LEED-NC v2009			Corporate: Privately Held	Office: Administrative/Professional
Al Jaber Building Headquarters	Doha	LEED-NC v2009			Corporate: Privately Held	Office: Administrative/Professional
Confidential	Confidential	LEED-NC v2009			Confidential	Public Assembly: Stadium/Arena
Confidential	Confidential	LEED-ND v2009 Stage 1			Confidential	Non-residential and Residential
MENA OFFICE BUILDING (ECQ-B11)	DOHA	LEED-CS v2009			Corporate: Privately Held	Office: Mixed-Use
QU- Student Housing Master Site	Doha	LEED-NC v2009	23		Educational: University, Public	Multi-Family Residential: Apartment
QU-Student Housing - Hostel - Female	Doha	LEED-NC v2009	48			Multi-Family Residential: Apartment
QU-Student Housing-Hostel-Male	Doha	LEED-NC v2009	48		Educational: University, Public	Multi-Family Residential: Apartment
QU-Student Housing-Apartment-1	Doha	LEED-NC v2009	48		Educational: University, Public	Multi-Family Residential: Apartment
QU-Student Housing-Apartment-2	Doha	LEED-NC v2009	48		Educational: University, Public	Multi-Family Residential: Apartment
QU-Student Housing-	Doha	LEED-NC	48		Educational: University,	Multi-Family Residential: Apartment

Apartment-3		v2009		Public	
QU-Student Housing-Apartment-4	Doha	LEED-NC v2009	48	Educational: University, Public	Multi-Family Residential: Apartment
QU-Student Housing-Apartment-5	Doha	LEED-NC v2009	53	Educational: University, Public	Multi-Family Residential: Apartment
QU-Student Housing-Apartment-6	Doha	LEED-NC v2009	53	Educational: University, Public	Multi-Family Residential: Apartment
QU-Student Housing-Apartment-7	Doha	LEED-NC v2009	53	Educational: University, Public	Multi-Family Residential: Apartment
QU-Student Housing-Apartment-8	Doha	LEED-NC v2009	53	Educational: University, Public	Multi-Family Residential: Apartment
QU-Student Housing-Apartment-9	Doha	LEED-NC v2009	53	Educational: University, Public	Multi-Family Residential: Apartment
QU-Student Housing-Apartment-10	Doha	LEED-NC v2009	53	Educational: University, Public	Multi-Family Residential: Apartment
QU-Student Housing-Club House	Doha	LEED-NC v2009	41	Educational: University, Public	Public Assembly: Social/Meeting
QU-Student Housing-Administration Bldg	Doha	LEED-NC v2009	48	Educational: University, Public	Office: Administrative/Professional
QU-Student Housing-Maintenance Bldg	Doha	LEED-NC v2009	45	Educational: University, Public	Office: Administrative/Professional
QSTP Testing Facility	Doha	LEED-NC v2009	6		Warehouse: General
Al Mana Hotel	Doha	LEED-NC v2009		Corporate: Privately Held	Multi-Family Residential: Apartment
Confidential	Confidential	LEED-NC v2009		Confidential	Office: Mixed-Use
Confidential	Confidential	LEED-NC v2009		Confidential	Religious Worship
Confidential	Confidential	LEED-NC v2009		Confidential	Multi-Family Residential: Apartment
Confidential	Confidential	LEED-NC		Confidential	Multi-Family Residential: Apartment

		v2009		
Confidential	Confidential	LEED-CS v2009	Confidential	Office: Mixed-Use
Confidential	Confidential	LEED-NC v2009	Confidential	Lodging: Hotel/Motel/Resort, Full Service
Confidential	Confidential	LEED-NC v2009	Confidential	Public Assembly: Entertainment
Confidential	Confidential	LEED-NC v2009	Confidential	Lodging: Other lodging
Confidential	Confidential	LEED-NC v2009	Confidential	Multi-Family Residential: Apartment
Confidential	Confidential	LEED-NC v2009	Confidential	Multi-Family Residential: Apartment
Confidential	Confidential	LEED-NC v2009	Confidential	Multi-Family Residential: Condominium
Confidential	Confidential	LEED-NC v2009	Confidential	Multi-Family Residential: Apartment
Confidential	Confidential	LEED-CS v2009	Confidential	Office: Administrative/Professional
Confidential	Confidential	LEED-NC v2009	Confidential	Service: Other Service
Confidential	Confidential	LEED FOR SCHOOLS v2009	Confidential	Core Learning Space: K-12, Elementary/Middle School
Confidential	Confidential	LEED-NC v2009	Confidential	Multi-Family Residential: Apartment
Confidential	Confidential	LEED-NC v2009	Confidential	Multi-Family Residential: Apartment
Confidential	Confidential	LEED-NC v2009	Confidential	Multi-Family Residential: Apartment
Confidential	Confidential	LEED-CS v2009	Confidential	Office: Mixed-Use
Confidential	Confidential	LEED-CS v2009	Confidential	Office: Mixed-Use
Confidential	Confidential	LEED-CS v2009	Confidential	Office: Mixed-Use
Confidential	Confidential	LEED-CS v2009	Confidential	Office: Mixed-Use
Confidential	Confidential	LEED-NC v2009	Confidential	Service: Other Service
Confidential	Confidential	LEED-CS v2009	Confidential	Retail: Other Retail
Confidential	Confidential	LEED-NC v2009	Confidential	Multi-Family Residential: Apartment
Confidential	Confidential	LEED-CS v2009	Confidential	Office: Mixed-Use

Confidential	Confidential	LEED-CS v2009		Confidential	Office: Mixed-Use
Confidential	Confidential	LEED-NC v2009		Confidential	Multi-Family Residential: Apartment
Confidential	Confidential	LEED-CS v2009		Confidential	Office: Mixed-Use
Confidential	Confidential	LEED-NC v2009		Confidential	Lodging: Hotel/Motel/Resort, Select Service
Confidential	Confidential	LEED-CS v2009		Confidential	Office: Mixed-Use
Confidential	Confidential	LEED-NC v2009	16	Confidential	Service: Other Service
Confidential	Confidential	LEED-NC v2009	30	Confidential	Multi-Family Residential: Apartment
Confidential	Confidential	LEED-NC v2009	34	Confidential	Multi-Family Residential: Apartment
Confidential	Confidential	LEED-NC v2009	34	Confidential	Multi-Family Residential: Apartment
Confidential	Confidential	LEED-NC v2009	34	Confidential	Multi-Family Residential: Apartment
Confidential	Confidential	LEED-NC v2009	30	Confidential	Multi-Family Residential: Apartment
Confidential	Confidential	LEED-NC v2009	32	Confidential	Multi-Family Residential: Apartment
Confidential	Confidential	LEED-NC v2009		Confidential	Religious Worship
Confidential	Confidential	LEED-NC v2009	34	Confidential	Multi-Family Residential: Apartment
Confidential	Confidential	LEED-CS v2009	31	Confidential	Retail: Other Retail
Confidential	Confidential	LEED-NC v2009	29	Confidential	Multi-Family Residential: Apartment
Confidential	Confidential	LEED-NC v2009	22	Confidential	Lodging: Hotel/Motel/Resort, Select Service

Confidential	Confidential	LEED-NC v2009	Confidential	Service: Other Service
Confidential	Confidential	LEED-CS v2009	Confidential	Office: Mixed-Use
Confidential	Confidential	LEED-CS v2009	Confidential	Office: Mixed-Use
Confidential	Confidential	LEED-NC v2009	Confidential	Multi-Family Residential: Apartment
Confidential	Confidential	LEED-NC v2009	Confidential	Multi-Family Residential: Apartment
Confidential	Confidential	LEED-NC v2009	Confidential	Lodging: Hotel/Motel/Resort, Select Service
Confidential	Confidential	LEED-NC v2009	Confidential	Multi-Family Residential: Apartment
Confidential	Confidential	LEED-CS v2009	Confidential	Office: Mixed-Use
Confidential	Confidential	LEED-CS v2009	Confidential	Office: Mixed-Use
Confidential	Confidential	LEED-CS v2009	Confidential	Office: Mixed-Use
Confidential	Confidential	LEED-CS v2009	Confidential	Office: Mixed-Use
Confidential	Confidential	LEED-CS v2009	Confidential	Retail: Other Retail
Confidential	Confidential	LEED-NC v2009	Confidential	Service: Other Service
Confidential	Confidential	LEED-NC v2009	Confidential	Public Assembly: Other Assembly
Confidential	Confidential	LEED-NC v2009	Confidential	Public Assembly: Other Assembly
Confidential	Confidential	LEED-NC v2009	Confidential	Public Assembly: Other Assembly
Confidential	Confidential	LEED-NC v2009	Confidential	Religious Worship
Confidential	Confidential	LEED-NC v2009	Confidential	Public Assembly: Other Assembly
Confidential	Confidential	LEED FOR SCHOOLS v2009	Confidential	Core Learning Space: K-12, High School
QF Student Housing Phase 2 Bldg 5 F	Doha	LEED-NC v2009	Educational: University, Private	Lodging: Dormitory
Confidential	Confidential	LEED-NC v2009	Confidential	Multi-Family Residential: Apartment
Confidential	Confidential	LEED-NC v2009	Confidential	Multi-Family Residential: Apartment

Qatar Petroleum RTC	Doha	LEED-CI v2009		Government Use: Other (utility, airport,	Office: Other Office
Majlis and Mosque Al Attiyah	Doha	LEED-NC v2009		Corporate: Privately Held	Religious Worship
Confidential	Confidential	LEED-CI v2009	43	Confidential	Office: Administrative/Professional
JCI Doha Renaissance Tower	Doha	LEED-CI v2009		Corporate: Publicly Traded	Office: Administrative/Professional
Qatar Cool District Cooling Plant 3	Doha	LEED-NC v2009		Corporate: Privately Held	Service: Other Service
Confidential	Confidential	LEED-NC v2009		Confidential	Lodging: Hotel/Motel/Resort, Full Service
Office Building	Doha	LEED-NC v2009		Corporate: Privately Held	Office: Administrative/Professional
Confidential	Confidential	LEED-CI v2009	33	Confidential	Office: Government
Al Majaz II	Doha	LEED-CS v2009		Corporate: Privately Held	Office: Mixed-Use
Confidential	Confidential	LEED-CS v2009	51	Confidential	Laboratory
Health and Wellness Facilities - EC	Doha	LEED-NC v2009		Educational: University, Public	Public Assembly: Stadium/Arena
Confidential	Confidential	LEED-ND v2009 Stage 2		Confidential	Non-residential and Residential
Arab Engineeing Bureau HQ	Doha	LEED-EB:OM v2009		Corporate: Privately Held	Office: Administrative/Professional
Premier Inn Hotel	Doha	LEED-NC v2009		Corporate: Privately Held	Lodging: Hotel/Motel/Resort, Full Service
Confidential	Confidential	LEED FOR SCHOOLS v2009		Confidential	Core Learning Space: K-12, Elementary/Middle School
Confidential	Confidential	LEED FOR SCHOOLS v2009		Confidential	Core Learning Space: K-12, Elementary/Middle School
Confidential	Confidential	LEED FOR SCHOOLS v2009		Confidential	Core Learning Space: K-12, Elementary/Middle School
Confidential	Confidential	LEED FOR SCHOOLS v2009		Confidential	Core Learning Space: K-12, Elementary/Middle School
Confidential	Confidential	LEED FOR SCHOOLS v2009		Confidential	Core Learning Space: K-12, Elementary/Middle School

Confidential	Confidential	LEED FOR SCHOOLS v2009		Confidential	Core Learning Space: K-12, Elementary/Middle School
Confidential	Confidential	LEED-ND v2009 Stage 1		Confidential	Residential
Confidential	Confidential	LEED-ND v2009 Stage 2		Confidential	Non-residential and Residential
HBKU Faculty and Staff Club Building	Doha	LEED-NC v2009	7	Non-Profit (that do not fit into other c	Office: Other Office
HBKU Faculty and Staff Club Souq	Doha	LEED-CS v2009	8	Non-Profit (that do not fit into other c	Retail: Open Shopping Center
HBKU Faculty and Staff Club Bank	Doha	LEED-CS v2009	8	Non-Profit (that do not fit into other c	Retail: Bank Branch
Confidential	Confidential	LEED-NC v2009	7	Confidential	Lodging: Hotel/Motel/Resort, Full Service
Confidential	Confidential	LEED-NC v2009	10	Confidential	Lodging: Hotel/Motel/Resort, Full Service
Confidential	Confidential	LEED-NC v2009	30	Confidential	Lodging: Hotel/Motel/Resort, Full Service
Standard Chartered	Doha	LEED-CI v2009		Investor: Bank	Office: Financial
LEE EB-OM CertificWomen Science College	Doha	LEED-EB:OM v2009		Educational: University, Public	Core Learning Space: College/University
LEED EB-OM Certif Women Activity center	Doha	LEED-EB:OM v2009		Government Use: State	Core Learning Space: College/University
LEED EBOM Cert Central Service Unit	Doha	LEED-EB:OM v2009		Government Use: State	Core Learning Space: College/University
Jafna Qatar	Doha	LEED-NC v2009		Corporate: Privately Held	Industrial Manufacturing
Confidential	Confidential	LEED-NC v2009		Confidential	Public Assembly: Recreation
Confidential	Confidential	LEED-NC v2009		Confidential	Public Assembly: Recreation
Confidential	Confidential	LEED-NC v2009		Confidential	Public Assembly: Recreation
Confidential	Confidential	LEED-NC v2009		Confidential	Public Assembly: Recreation
Confidential	Confidential	LEED-NC v2009		Confidential	Service: Other Service

North St Housing Master Site	Doha	LEED-NC v2009	Investor: Equity Fund	Core Learning Space: College/University
2BG4 Apartment Building	Lusail City	LEED-NC v2009	Corporate: Privately Held	Multi-Family Residential: Apartment
Confidential	Confidential	LEED-NC v2009	Confidential	Public Assembly: Stadium/Arena
RasGas Headquarters Building	Doha	LEED-EB:OM v2009	Government Use: Other (utility, airport,	Office: Administrative/Professional
QSTP Tech 4 Building	Doha	LEED-CS v2009		Other
Confidential	Confidential	LEED v4 BD+C: NC	Confidential	Public Assembly: Stadium/Arena
Al Rayyan Stadium	Doha	LEED v4 BD+C: NC		Public Assembly: Stadium/Arena
Confidential	Confidential	LEED-ND v2009 Stage 1	Confidential	Non-residential and Residential
RDC Fundamental Science Building	Education City	LEED v4 BD+C: NC		Core Learning Space: College/University
MEEZA Offices	DOHA	LEED-NC v2009	Non-Profit (that do not fit into other c	Office: Administrative/Professional
Qatar Hospital	Doha	LEED v4 BD+C: HC		Health Care: Clinic/Other Outpatient
Confidential	Confidential	LEED-CS v2009	Confidential	Retail: Enclosed Mall
Qatar Academy Sidra	Doha	LEED v4 BD+C: SC	Investor: Bank	Core Learning Space: K-12 Elementary/Middle School
TBD		LEED-HOMES v2008		
Doha-Msheireb Downtown Doha		LEED-HOMES v2008		

Appendix D: Sample of electricity readings records at QU

STATE
OF
QATAR
UNIVERSITY OF
QATAR
BUSINESS
OPERATIONS
DEPARTMENT
ELECTRO-
MECHANICAL
SECTION

SUBJECT: UTILITY METERS READING AT QU, AL TARFA Area, as of	

SN	S/S No.	LOCATIONS	ELECTRI-CITY No.	METER NO.	1-Dec-12	1-Jan-13	1-Feb-13	1-Mar-13	1-Apr-13
1		Q.K	123686	98266	5,005,900	5,030,900	5,052,230	5,073,520	5,104,170
2		C.S.U. No.1 HV	904480	9050596	387,293,000	387,728,000	388,104,000	388,504,000	388,943,000
3		C.S.U. No.2 HV	904481	9050597	511,246,000	512,384,000	513,334,000	514,366,000	515,599,000
4		XX	904603	104142	10,279	11,745	13,003	14,777	16,270
5		BD	904629	39480	536,105	539,854	543,332	547,808	552,138
6		GH	904656	78833	959,840	963,500	966,610	970,140	973,770
7		WOMEN'S CHILLERS 1&2	904682	77024	3,086,630	3,128,830	3,147,660	3,169,620	3,214,270
8		WOMEN'S CHILLERS 3&4	904683	77025	2,728,510	2,763,490	2,800,030	2,845,320	2,900,460

Appendix E: Sustainable FM practices

The Carbon Trust[4], the Energy Trust and the New Zealand Green Building Council (2011) have determined several key maintenance measurements for equipment and its handling during operation to reduce energy consumption and conserve resources. Also, many researchers, such as Azizi et al. (2014), Brauers (2004), and Li (2013), have mentioned that some practices should be adopted in the following categories:

5. Lights and lighting: Lighting diffusers and shades have to be cleaned or maintained on a regular planned schedule. Blinds and windows must be regularly cleaned, as well.

6. Sensors, such as room sensors, duct thermostats, humidistats, pressure sensors, temperature sensors, and meters should be checked on a regular basis and calibrated according to the Energy management system (EMS).

7. Fine tuning of control systems has to be done during the first year of operation.

8. Energy auditing plans and submeter recording:Submeters of building systems must be monitored and recorded to investigate energy consumption by major building processes. This consists of data collection regarding energy consumption figures,

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4The Carbon Trust is an independent expert partner of leading organizations around the world, helping them contribute to and benefit from a more sustainable future through carbon reduction, resource efficiency strategies, and commercialization of low-carbon technologies.

floor area, and temperature variations. After data collection, readings must be analyzed and interpreted to determine where energy could be reduced.

Operation and maintenance practices for sustainability

Azizi et al. (2014), Brauers (2004) and Li (2013) have mentioned other practices to be followed. Some of these important practices are as follows:

1. Energy schedules must be tested, commissioned and updated.

2. Scheduling: Detailed schedules are needed for every building and for different sections since scheduling for only some sections and parts is considered ineffective. According to LEED-EBOM (2009), scheduling techniques must consist of an equipment runtime schedule, an occupancy schedule and set points for all HVAC equipment and lighting levels. For instance, it is advised to set timing operations to turn off the HVAC around one hour before the end of the working day and to set a temperature of cooling systems between 20 °C and 24 °C.

3. Review and edit operating schedule strategies.

4. Exterior lighting schedule should be changed according to the season.

5. Motion sensor sensitivity and time delay settings must be customized according to the requirement of each individual space

6. Submeters must be taken into high consideration by recording, monitoring and analyzing energy consumption. This includes energy cost, temperature settings and surveys for user satisfaction.

7. Scheduled cleaning during opening of the building instead of after working hours in order to save energy that would otherwise be consumed if cleaning were to take place during separate hours at the end of the day.

8. Switch off the HVAC one hour or half an hour before closing the building after working hours in order to save energy.

9. Promote awareness and training for employees and users.

10. Try to eliminate user controls so as to standardize behavioral patterns.

11. Surveys to be conducted quarterly to identify systems, lights, and equipment in need of maintenance.

12. An energy report must contain reasons for an energy increase and recommended plans for additional improvements in energy efficiency. These kinds of reports are used to build historical baselines for comparison of energy consumption throughout a building's lifecycle.

13. Documentation must be prepared by the operation management team for facilities maintenance teams, highlighting the best practices for energy management to cure any defaults. Moreover, operation of building systems has to be recalibrated as advised by manufacturers.