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عمادة الدراسات العليا
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# ادارة الطاقة خلال مرحلة تنفيذ الانشاءات في قطاع غزة من وجهة نظر المقاولين

# Energy management during construction phase in Gaza Strip-Contractors' perspective

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# إقــــــرار

أنا الموقع أدناه مقدم الرسالة التي تحمل العنوان:

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**إدارة الطاقة خلال مرحلة التنفيذ للانشاءات في قطاع غزة من وجهة نظر المقاولين**

**Energy Management during Construction phase in Gaza Strip-Contractor Perspective**

وبعد المناقشة العلنية التي تمت اليوم الأحد 21 ربيع الأول 1437هـ، الموافق 2016/01/31م الساعة الحادية عشرة صباحاً بمبنى القدس، اجتمعت لجنة الحكم على الأطروحة والمكونة من:

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***واللجنة إذ تمنحه هذه الدرجة فإنها توصيه بتقوى الله ولزوم طاعته وأن يسخر علمه في خدمة دينه ووطنه.***

والله ولي التوفيق،،،

**نائب الرئيس لشئون البحث العلمي والدراسات العليا**

**أ.د. عبدالرؤوف علي المناعمة**

بسم الله الرحمن الرحيم

**قال تعالى {وَقُلِ اعْمَلُوا فَسَيَرَى اللَّهُ عَمَلَكُمْ وَرَسُولُهُ وَالْمُؤْمِنُونَ وَسَتُرَدُّونَ إِلَى عَالِمِ الْغَيْبِ وَالشَّهَادَةِ فَيُنَبِّئُكُمْ بِمَا كُنْتُمْ تَعْمَلُونَ }**

صدق الله العظيم

(سورة التوبة: آية 105)

# Dedication

*"A light has gone out,*
*But its glory will never die*
*In the memories of those it shone upon,*
*Shed its warmth upon "*

(James Sexton, 1989)

The personal journey of learning and, hopefully, contribution this thesis represents I dedicate to my father, who died in 1998.

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*This thesis could not have been completed without the help and support of many peoples and institutions, to whom I am extremely grateful. Special thanks go to all interviewed personnel of Palestinian Contractors Union (PCU), Palestinian Central Bureau of Statistics (PCBS) and all the contractors who filled the questionnaire.*

*My heartfelt appreciation to my wonderful brothers and sisters for their support and encouragement in so many ways.*

*My heartfelt appreciation to my great family for their continuous understanding, support and encouragement, especially my mother and my wife, all the efforts and time they shared. They were standing beside me all the way, words cannot describe my appreciation for their inputs in my life both directly and indirectly.*

***Sincerely,***

***Abed El Rahman Ayyash,,,,***

# Abstract

**Purpose:** Energy management is an effective mean to lessen energy costs and greenhouse gas emissions as a result of energy use in construction activities. Construction industry practitioners worldwide are beginning to appreciate sustainable energy management and acknowledge the advantages of implementing energy management principles in construction projects. This study aims to assess the level of awareness about energy management among construction contractors in Gaza Strip, to measure the extent of practicing energy management and saving methods, to examine the drivers and the barriers that may exist toward implementing the practice of energy management and to explore the best activities to save energy in construction projects.

**Design/methodology/approach:** Various techniques were conducted in this study to collect needed data including, literature review, questionnaire survey and structured face-to-face interviews with several experts in construction and energy aspects. Questionnaire survey was conducted among professionals working in local construction contracting companies who have extensive experience in practicing construction projects. Questionnaires were distributed to 100 randomly selected contracting companies out of which 76 valid questionnaires were received and have made up of 30 from first class, 30 from second class and 16 from third class according to the Palestinian Contractors Union (PCU) classification system. Quantitative method was used for data analysis by using SPSS version 22. Mean square method and the relative importance index were used to identify the relative importance and ranking of each variable\statement used in the questionnaire. Exploratory factor analysis was therefore used for data reduction to establish which of the variables could be measuring aspects of the same underlying dimensions.

**Findings:** According to the responses received, the local construction contractors in Gaza Strip have a moderate degree of awareness about energy management. They have the highest level of awareness and most positive attitudes towards economic benefits related to energy management. Poor application level of energy management in local contractors emerged as a result of the lack of specified knowledge about techniques and strategies for energy management. It was also found that some energy management requirements are applied on a small scale with informal system and with nonprofessional approaches. The most effective driving force for local construction contractors to adopt energy management was, cost saving gained from adopted energy management strategies. “Additional costs needed to improve the company energy efficiency” was ranked in the first position from a list of barriers for energy management. Respondents also ranked the activity “Adoption of more energy efficient construction methods as opposed to traditional construction methods during construction phase” as the most effective activity for energy saving in construction projects.

Factor analysis method performed on the initial data of each list related to the drivers, barriers and activities for energy management. Four grouping factors emerged from the 19 drivers remained in the final solution which are “Economic and Financial”; “Institutional and Legal”; “Organizational and Managerial” and “Education and Information”. Four factors also extracted from the remained 28 barriers in the final solution which are: "Economic and Financial"; "Knowledge and Information"; "Legal and Contractual" and "Organizational and Management". The activities to save energy have been clustered in four factors from the remained 27 activities in the final solution, which are: "Information and Communication"; "Techniques and Technology"; "Equipment and Materials" and "Regulation and Management".

The finding also indicated that local construction industry stakeholders should come up with a special educational and training programs, legislations and standards related to energy efficient construction practices specific to Gaza's construction environment.

**Theoretical and practical implications of the research:** This study can provide a reference for studying the effective practices in order to obtain the efficient energy use in construction projects. It also provides a valuable information for studying the practice of energy management development in other industries. In addition, this study will allow construction contracting companies to understand where they fall within energy saving and sustainability issues and to devise a strategy to be developed to attain higher levels of sustainable energy management. Overall, this study nature and findings will attract the attention of the local contracting companies to the importance and impacts of energy management application in their activities and therefore, greater acceptance will be generated for the adoption of efficient energy practices in local construction sector.

**Originality/value:** This study presents the first investigation into energy management issue in Gaza Strip construction industry, especially from contracting organizations perspective. This study results will open the door for more discussions about all subjects related to energy use, saving and impacts in construction projects. The results of this study can be of good help to policy makers, researchers and industry practitioners (clients, contractors, consultants and others) in energy management related aspects.

**Keywords:** Construction industry, Energy management, Energy efficiency, Sustainability, Sustainable construction, Green construction, Contractors, Gaza Strip.

# ملخص البحث

**الغرض من الدراسة:** تعتبر إدارة الطاقة كأحد الوسائل الفاعلة في تقليل تكاليف الطاقة وغازات الاحتباس الحراري المنبعثة من استخدام موارد الطاقة في الأنشطة المتعلقة بالمشاريع الانشائية. لذلك بدأ العديد من العاملين في صناعة الانشاءات حول العالم بإدراك أهمية ادارة الطاقة و الآثار الايجابية الناتجة من تطبيقها في المشاريع الانشائية. تهدف هذه الدراسة لبناء تصور حول الية ادارة الطاقة في شركات المقاولات العاملة في صناعة الانشاءات في قطاع غزة من خلال تحقيق خمسة أهداف مقترحة للدراسة في هذا البحث وهي استكشاف مدى وعي المقاولين المحليين لأهمية إدارة الطاقة بجانب تحديد مستوى تطبيقها في شركات الانشاءات المحلية خلال تنفيذ المشاريع الانشائية. بالإضافة الى التعرف على الدوافع والمعيقات أمام تطبيق المقاولين المحليين لمبادئي ادارة الطاقة في المشاريع الانشائية خلال مرحلة التنفيذ. وتهدف هذه الدراسة أيضا للتعرف على وجهة نظر المقاولين المحليين في أفضل الممارسات التي يمكن القيام بها لتقليل استهلاك الطاقة خلال تنفيذ المشاريع الانشائية.

**منهجية البحث:** لتحقيق أهداف هذه الدراسة تم اختيار طرق البحث الكمي باستخدام الاستبانة. حيث أنه تم اعداد استبانة من خلال تجميع أكبر قدر من المعلومات والمتغيرات المتعلقة بموضوع الدراسة عن طريق إجراء مراجعة العديد من الدراسات والتقارير الصادرة سابقا والمتعلقة بموضوع البحث. تم بعد ذلك مراجعة وتدقيق وتنقيح المعلومات من خلال إجراء العديد من المقابلات مع عدد من الأشخاص الذين لديهم خبرة واسعة في صناعة الانشاءات والطاقة. مجتمع الدراسة يشمل المقاولين المؤهلين من درجات التصنيف الثلاثة الأولى فقط في قطاع غزة حسب أنظمة اتحاد المقاولين حيث أنه قد تم توزيع الاستبانة على عينة تشمل 100 مقاول من مجتمع الدراسة وتم جمع 86 استبانة منها 76 استبانة مكتملة وصالحة للدراسة تتكون من 30 استبانة من مقاولي الدرجة الاولى و 30 من مقاولي الدرجة الثانية و 16 من مقاولي الدرجة الثالثة. تم تحليل بيانات الاستبانات باستخدام البرنامج الاحصائي SPSS حيث تم الاعتماد على العديد من الوسائل الاحصائية الوصفية مثل مؤشر الأهمية النسبية (RII) والتحليل العاملي Factor analysis بجانب استخدام وسائل الاحصاء الاستدلالي.

**نتائج الدراسة:** أشارت الدراسة الى أن المقاولين المحليين لديهم مستوى وعي مقبول بقضية ادارة الطاقة وأهميتها وأظهرت الدراسة أيضا أن تطبيق مبادي ادارة الطاقة محدود جدا في شركات المقاولات العاملة في قطاع غزة ويتم ذلك بشكل غير منظم وغير مهني. بجانب ذلك أشارت نتائج هذه الدراسة إلى أن المقاولين المحليين يعتبرون أن العديد من العوامل يمكنها تحفيزهم لتطبيق ادارة الطاقة وأهم هذه العوامل من وجهة نظرهم هو التوفير في تكاليف المشروع نتيجة تطبيق ادارة الطاقة. وأوضح المقاولون أن أهم المعيقات لإمكانية تطبيق ادارة الطاقة محليا هو التكاليف الاضافية الأولية اللازمة لتطبيق هذه الفكرة في الشركة. ويعتقد المجيبون أن أفضل وسيلة يمكن من خلالها الحصول على أكبر قدر من التوفير في الطاقة في المشاريع الانشائية هي تطبيق وسائل انشاء حديثة وأكثر فاعلية في توفير الطاقة من الوسائل التقليدية المطبقة في الوقت الحالي .

وأشارت نتائج التحليل العاملي لإمكانية تقليص عدد العوامل المستخدمة في الدراسة لعدد أقل يمثل هذه العوامل كاملة حيث أوضحت أن الدوافع لتطبيق ادارة الطاقة في الشركات المحلية يمكن تصنيفها في أربعة عوامل رئيسية وهي "عوامل اقتصادية ومالية" و " عوامل مؤسساتية و قانونية" و " عوامل تنظيمية وادارية" والعامل الرابع هو " التعليم والمعلومات". وأظهرت نتائج التحليل العاملي لإمكانية دمج المعيقات لتطبيق ادارة الطاقة في اربعة عوامل رئيسية وهي

" عوامل اقتصادية ومالية" و "عوامل تتعلق بالمعرفة والمعلومات" و "عوامل قانونية وتعاقدية" والعامل الرئيسي الرابع هو "عوامل تنظيمية وادارية". أما أفضل الوسائل لتوفير الطاقة فقد تم ادراجها في اربعة عوامل رئيسية وهي " المعلومات والاتصال" و " التكنولوجيا والتقنيات" و" المعدات والمواد" و العامل الرابع هو " القوانين والادارة".

نتائج هذه الدراسة تشير بشكل معمق لأهمية التعليم والتدريب للعاملين في صناعة الانشاءات حول قضية ادارة الطاقة بجانب توفير القوانين والانظمة الملزمة لتطبيق هذه الفكرة في شركات المقاولات المحلية.

**الآثار النظرية والعملية للدراسة:** يمكن لهذه الدراسة بمحتواها ونتائجها أن تمثل مرجعا للباحثين لدراسة أفضل الوسائل لتوفير الطاقة في صناعة الانشاءات. بجانب أنه يمكن للصناعات الاخرى العاملة محليا الاستفادة من هذه الدراسة لدراسة القضايا المتعلقة بإدارة الطاقة. هذه الدراسة يمكنها أيضا أن تمكن المقاولين المحلين من معرفة موقع شركاتهم بالنسبة للقضايا المتعلقة بديمومة وادارة الطاقة لتحديد التوصيات اللازمة لتطبيق استراتيجيات ادارة الطاقة بشكل موسع في شركاتهم. بجانب أن نتائج هذه الدراسة تعمل على لفت انتباه المقاولين في قطاع غزة وفلسطين بشكل عام لأهمية ادارة الطاقة وخلق حالة من القبول لديهم لتطبيقها من خلال استخدام ممارسات أكثر فاعلية في توفير الطاقة في مشاريع التشييد.

**قيمة الدراسة:** تعتبر هذه الدراسة أول دراسة حول موضوع ادارة الطاقة في صناعة الانشاءات في قطاع غزة خصوصا دراسة هذه القضية من وجهة نظر المقاولين. بالتالي ستعمل هذه الدراسة على فتح الباب بشكل واسع لمناقشة ودراسة جميع المسائل والمقترحات المتعلقة باستخدام الطاقة وطرق توفيرها في صناعة الانشاءات. بجانب أن نتائج هذه الدراسة يمكنها أن توفر المساعدة الجيدة لمتخذي القرار والباحثين وجميع الأطراف العاملة في صناعة الانشاءات ( المالكين والمانحين والاستشاريين والعاملين وغيرهم) حول المواضيع المتعلقة بإدارة الطاقة.

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# List of abbreviations

| Abbreviation | Abbreviation description |
|---|---|
| $CO_2$ | Carbon Dioxide |
| EFA | Exploratory Factor Analysis |
| EMs | Energy Management System |
| GDP | Gross Domestic Product |
| GHG | Green House Gas |
| LEED | Leadership in Energy and Environmental Design Method |
| NCC | National Classification Committee |
| PCA | Principal Component Analysis |
| PCBS | Palestinian Central Bureau of Statistics |
| PCU | Palestinians Contractors Union |
| PEA | Palestinian Energy Authority |
| SMEs | Small and Medium-Sized Enterprises |
| UNDP | United Nations Development Program |
| UNRWA | United Nations Relief and Works Agency |

Chapter 1

# Introduction

This chapter provides an introduction to this thesis. It presents the background, and historical information about Gaza Strip, local construction industry and energy sector situation in Gaza Strip which related to the subject of this thesis. Problem background, importance and benefits to choose the thesis subject are clarified. Aim and objectives along with research limitations and scope are identified. Short discussion about the thesis structure and methodology used also has been provided.

## 1.1 Gaza Strip profile

Gaza Strip is a narrow land area located in the South-eastern Mediterranean sea with average maximum length of 45 km between the boundary near Beit Hanoun in the north, and Rafah on the Palestinian-Egyptian border in the south Figure (1.1). Its width varies from 6 km along the line traversing through Deir El Balh in the center, to 13 km along the Palestinian-Egyptian boundary in the south (PASSIA, 2008). It borders Israel to the east and north and Egypt to the south. There are approximately 1.76 million inhabitants living in the Gaza Strip in an area comprising 365 $km^2$, which makes it one of the most densely populated areas in the world. Almost 80% of them being registered refugees who were uprooted and displaced from their homes in 1948 in what is now the state of Israel (MoPAD, 2012; PCBS, 2014). In addition, Gaza is almost ten times more densely populated than the West Bank and twelve times more than Israel. Gaza Strip has a temperate climate, with mild winters and dry, hot summers subject to drought. Average rainfall is about 300 mm. The terrain is flat or rolling, with dunes near the coast (UNEP, 2009; Muhaisen and Ahlbäck, 2012; PCBS, 2014).

Five border crossings linking Gaza Strip to the outside world; four with Israel and one with Egypt. All materials and goods required for the people in the Gaza Strip are officially to enter through the Israeli border crossings, whereas the Egyptian crossing is only for persons' movement. Access to the Mediterranean Sea is limited to three nautical miles along the Gaza coastline (Muhaisen and Ahlbäck, 2012). However, Gaza Strip has been subject to many external and internal political, economic and social pressures that led to poor socioeconomic conditions for its population. Furth more, with lack of natural resources and consequent extremely high dependency on Israel, Gaza Strip has suffered mostly during the second Intifada and during the subsequent years from destruction and economic decline. Since 2006, Gaza Strip has been under siege; its external borders are largely sealed, with limited imports of vital goods and no exports worth mentioning.

Figure (1.1): Gaza Strip Map. (Source: PASSIA, 2008)

Enshassi (2000) reported that, Gaza Strip is one of the areas in the region which is expected to undergo considerable economic development in the coming years. In 2010-2011, the annual average real GDP growth of Gaza exceeded 20 percent, reflecting largely a rebound from the relaxation of Israeli restrictions on a range of imports following a period of tight restrictions. The growth was driven mainly by services and construction, while agriculture and manufacturing continued to be constrained by the virtual ban on exports (PCBS, 2014).

## 1.2 Construction sector in Palestine

Construction industry is one of the most important industries in all countries. In fact, it plays an important role in the economic and social development of nations. It consists of several activities such as, design, production, building, alteration or maintenance of the built environment and it includes several participants such as, manufacturers and suppliers of construction materials, clients, contractors, consultants and end users of facilities (Baloi, 2003). In general, construction industry considered as broad process/mechanism for the realization of human settlements and the creation of infrastructure that supports development. Construction process/mechanism includes the extraction and beneficiation of raw materials, the manufacturing of construction materials and components, the construction project cycle from feasibility to deconstruction, and the management and operation of the built environment (Plessis, 2002). Construction, renovation, and maintenance of buildings contributing 10 - 40% of countries' Gross Domestic Product (GDP) and representing on a global average 10% of country-level employment, 74% of which are in developing countries and 90% are with firms of fewer than ten people (UNEP-SBCI, 2009). When allied to other sectors and industries in material production and distribution, as well as service sectors such as transport, finance and the property market, its impact on society and the environment and its influence on the character of our world is tremendous (Alsubeh, 2013). Furth more , construction industry has a significant impact on the environment (Baloi, 2003).

In Palestinian context, construction sector playing a crucial role in extending job opportunities for Palestinian labor force. The Palestinian Central Bureau of Statistics (PCBS) indicated that 15.6 % of the employed persons in the West Bank and Gaza Strip were working in construction as seen in Table (1.1). On other hand, Figure (1.2) shows that, construction industry contributed in year 2013 by 14.1% of the Palestinians GDP (PCBS, 2014). This sector also employs about 30% of laborers indirectly in industries related to the construction sector and other services and productive sectors (PCU, 2008). However, local construction industry suffered great losses in term of quality, cost, and delay in handling projects due the policy of Israeli closure of the crossing points (PCHR, 2010).

Table (1.1): Percentage distribution of employed persons aged 15 years and above in Palestine by economic sector, 2010-2013. (Source: PCBS, 2014)

| Economic Sector | 2010 | 2011 | 2012 | 2013 |
|---|---|---|---|---|
| Agriculture, hunting, forestry and fishing | 11.8 | 11.9 | 11.4 | 10.5 |
| Mining, quarrying and manufacturing. | 11.4 | 11.8 | 11.9 | 12.2 |
| Construction | 13.2 | 13.9 | 14.4 | 15.6 |
| Commerce, hotels and restaurants | 19.3 | 20.3 | 19.6 | 19.6 |
| Transportation, storage and communications | 6.0 | 6.1 | 6.5 | 6.4 |
| Services and other branches | 38.3 | 36 | 36.2 | 35.7 |
| Total | 100 | 100 | 100 | 100 |

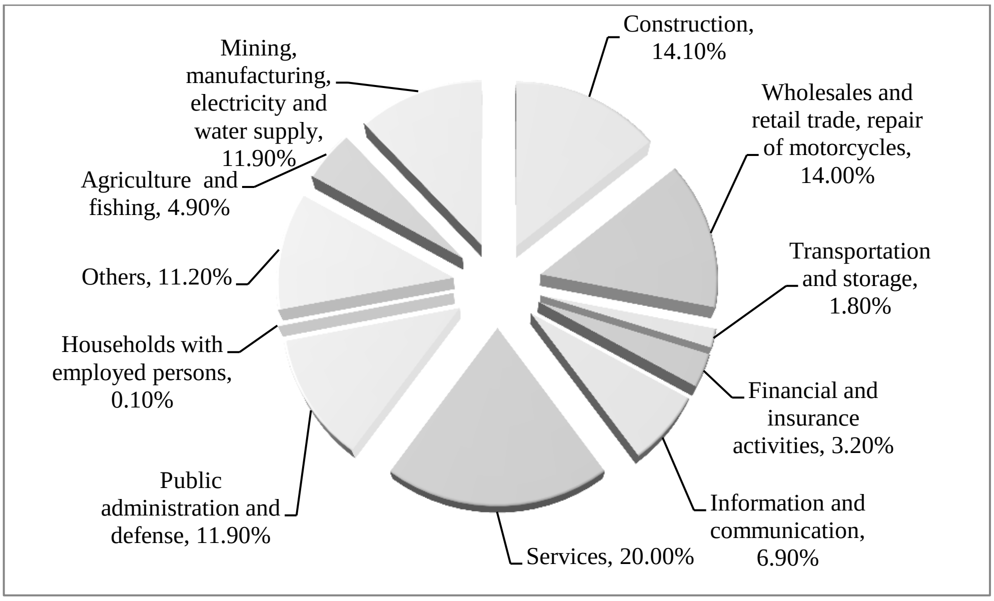


Figure (1.2): Percentage contribution to GDB by economic sector in Palestine (Base year 2004) (Source: PCBS, 2014)

Construction sector is considered as one of the most important sectors of industries for the Palestinian economy and plays a major role in the infrastructure facilities development. Mainly it relies on the local workforce and the raw materials which are imported from outside through borders crossings with Israel. Otherwise, border crossings closure imposed on the Gaza Strip since uprising of Al Aqsa intifada has left grave impacts on the Palestinian economic, social, cultural, civil and political rights, and obviously on construction industry (PCHR, 2010). This caused a severe shortage of raw materials and increase in the cost of these materials for users. Consequently, major local construction projects including buildings, roads and sewage system have been completely stopped due to preventing the entry of raw materials, especially cement, aggregate and steel. It is worth mentioning that construction materials were the first items to be banned upon the inception of the blockade. Israel continued to keep these materials on the blocked items list until early 2010. The pressure from the international community resulted in partial allowance of some materials. But the quantities allowed were not sufficient for major projects. The continued international pressure has led to the entry of such materials, under the responsibility of the international agencies like United Nations Relief and Works Agency (UNRWA) and United Nations Development Program UNDP. Moreover, building and construction in Gaza use scarce land and utilize many physical inputs. Their products are used for most productive and social activities and, owing to their durability, continuously interact with the physical environment. Construction can be a vehicle for erecting schemes for protecting the environment. Environmental issues are seldom considered on construction projects in Palestine because of the emergency nature of the projects (Enshassi, 2000).

Construction contracting considered as the core of construction sector in Palestine. Eventually, Palestinian contractors have proved their national role and outstanding ability in construction and reconstruction during Israeli incursions, when they have worked hard to maintain and reconstruct the infrastructure and buildings damaged by Israeli armed forces. Palestinian Contractors Union (PCU) member is a registered contractors who acquires a classification grade according to the standards specified in the “instructions of contractor classification” issued by the National Classification Committee (NCC). According to specialty, contractors' classification in the construction sector contains five main fields: Roads, Buildings, Electro-mechanics, Water and sewage, and Public works. Each main field has many sub-fields and each sub-field is classified under various classes as shown in Table (1.2) (PNA, 1994). In each field there are five different classes acquired for the contractor according to his performance in different areas as shown in Table (1.3). In order to get the required class, the contractor must accomplish all the requirements needed for classification. The main difference between the classification degrees for the same field or for different fields is determinant in three items as follows: classification requirements and conditions, machineries and equipment, and technical and financial staffs of contractor. Classification requirements and conditions are such as; capital, value of executed projects, office area, etc. Machineries and equipment are such as; mixers, trucks, diggers, etc. Technical and financial staffs are engineers, surveyors, technicians, secretaries, directors, etc.

Table (1.2): Classification degrees of main fields and sub-fields of works in Palestine

| Sub-field | Classification degree | | | | | |
|---|---|---|---|---|---|---|
| **Main field 1: Roads** | | | | | | |
| Roads | First A | First B | Second | Third | Fourth | Fifth |
| Pavement mixes | First | Second | Third | --- | --- | --- |
| Bridges | First | Second | Third | --- | --- | --- |
| Land works | First | Second | Third | --- | --- | --- |
| **Main field 2: Buildings** | | | | | | |
| Buildings | First A | First B | Second | Third | Fourth | Fifth |
| Ready concrete | First | Second | Third | --- | --- | --- |
| Steel structure | First | Second | Third | --- | --- | --- |
| Ready buildings | First | Second | Third | --- | --- | --- |
| Maintenance | First | Second | Third | Fourth | --- | --- |
| **Main field 3: Electro-mechanic** | | | | | | |
| Electro-mechanic | First | Second | Third | --- | --- | --- |
| Electro-mechanic maintenance | First | Second | Third | Fourth | --- | --- |
| Mechanic | First | Second | Third | Fourth | --- | --- |
| Electrical works | First | Second | Third | Fourth | --- | --- |
| Electronics | First | Second | Third | Fourth | --- | --- |
| **Main field 4: Water and sewage** | | | | | | |
| Water and sewage | First | Second | Third | Fourth | Fifth | --- |
| Purification stations | First | Second | --- | --- | --- | --- |
| Drainage | First | Second | --- | --- | --- | --- |
| **Main field 5: General works** | | | | | | |
| Excavation and mining | First | Second | --- | --- | --- | --- |
| Train rails | --- | --- | Third | Fourth | | |
| Wells and injection | First | Second | --- | --- | --- | --- |

Table (1.3): Requirements and conditions of contractors' classification (Source: PCU, 1994)

| Classification | Capital of company ($) | Equipment value ($) | Max. value of projects ($) | Max. value of a project ($) | Experience value of executed project ($) | Area of the office (m2) |
|---|---|---|---|---|---|---|
| **Field of work group 1: Infrastructure** | | | | | | |
| First class A | 650000 | 650000 | 8 million | 25 million | 8 million | 175 |
| First class B | 400000 | 400000 | 4 million | 8 million | 3 million | 140 |
| Second | 250000 | 250000 | 2 million | 4 million | 1 million | 120 |
| Third | 100000 | 100000 | 500000 | 1 million | 300000 | 75 |
| Fourth | 50000 | 50000 | 200000 | 500000 | 100000 | 50 |
| Fifth | 25000 | 25000 | 100000 | 200000 | 0 | 30 |

Table (1.3): Requirements and conditions of contractors' classification (Source: PCU, 1994) "Continued"

| Classification | Capital of company ($) | Equipment value ($) | Max. value of projects ($) | Max. value of a project ($) | Experience value of executed project ($) | Area of the office (m2) |
|---|---|---|---|---|---|---|
| **Field of work group 2 : Building** | | | | | | |
| First class A | 400000 | 300000 | 6 million | 15 million | 6 million | 150 |
| First class B | 250000 | 150000 | 3 million | 6 million | 3 million | 125 |
| Second | 100000 | 75000 | 1 million | 2 million | 1 million | 100 |
| Third | 75000 | 30000 | 500000 | 1 million | 500000 | 75 |
| Fourth | 30000 | 15000 | 250000 | 500000 | 150000 | 50 |
| Fifth | 10000 | 10000 | 100000 | 200000 | 0 | 30 |
| **Field of work group 3 : Water\Sewage** | | | | | | |
| First | 250000 | 250000 | 4 million | 8 million | 2 million | 140 |
| Second | 150000 | 150000 | 1 million | 4 million | 1 million | 120 |
| Third | 75000 | 75000 | 1 million | 2 million | 500000 | 75 |
| Fourth | 50000 | 50000 | 500000 | 1 million | 150000 | 50 |
| Fifth | 15000 | 15000 | 100000 | 200000 | 50000 | 30 |

## 1.3 Worldwide energy situation.

Different energy sources are provided worldwide. The Energy Information Administration (EIA) estimated the primary sources of energy in 2007 consisted of petroleum 36.0%, coal 27.4%, and natural gas 23.0%, amounting to an 86.4% share for fossil fuels in primary energy consumption in the world. Fossil fuels which include coal, petroleum, and natural gas continues to supply almost 80 percent of world energy use through 2040. Renewable energy and nuclear power are the world's fastest growing energy sources, each increasing by 2.5 percent per year (EIA, 2013).

Consumption of energy has deep implications on the world for humanity's social, economic and political sphere. The energy consumption per capita of majority of the population has been considerably increased especially in the developing countries. This energy growth has been realized recently due to major developments in several sectors such as residential, industrial and commercial (Ibrik and Mahmoud, 2005).The energy consumption in developed countries had grown at an average annual rate of 0.62 per cent and in the developing countries at an average rate of 4.36 per cent since 1996 (Jiang, 2008). EIA (2013) indicated that world marketed energy consumption is projected to increase by 56% from 2010 to 2040 Figure (1.3).Total world energy use will increased from 524 quadrillion British thermal units (Btu) in 2010 to 630 quadrillion Btu in 2020 and to 820 quadrillion Btu in 2040. Worldwide energy-related carbon dioxide emissions will rise from about 31 billion metric tons in 2010 to 36 billion metric tons in 2020 and then to 45 billion metric tons in 2040 ith 46-percent increase (EIA, 2013).

Many efforts have been done to resolve increased energy consumption and to reduce harmful climate impacts, the Kyoto Protocol and the Copenhagen agreements which are a UN agreement issued an "energy saving" and "low carbon economy" mandatory and moral initiative around the world to overcome the increased energy consumption and related greenhouse gas emissions (Chuanzhong and Yingji, 2011). Most countries considered energy issue seriously and have introduced policies to reduce energy consumption and greenhouse gas emissions through measures to improve energy efficiency (UNEP-SBCI, 2009). Industrial sector continues to account for the largest share of delivered energy consumption as it still consumes over half of global delivered energy in 2040. Energy is consumed in the industrial sector for a wide range of purposes, such as processing, assembly, producing steam, cogeneration, heating, air conditioning, and lighting in buildings (EIA, 2013). In the face of increasing demand for energy and especially electricity in all sectors, more efficient use of energy has to be considered as one of the major options to achieve global sustainable development in the 21st Century (Akinbami and Lawal, 2009).

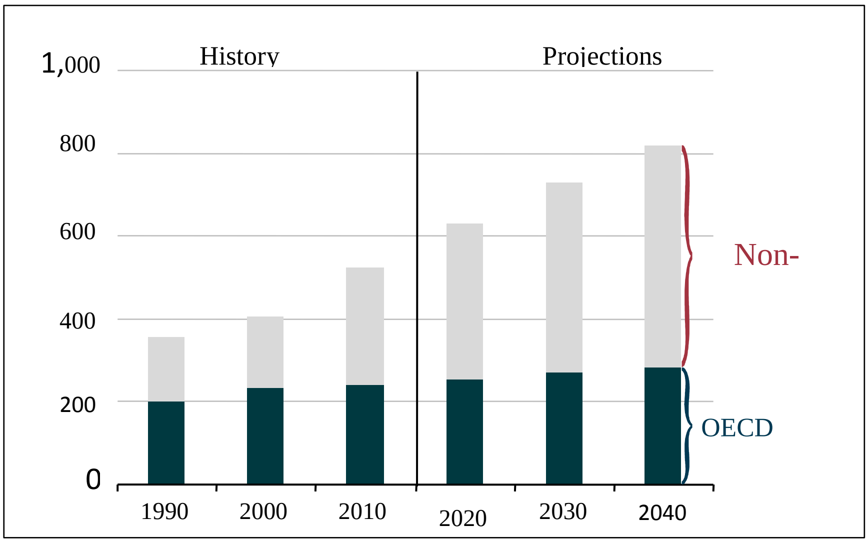


Figure (1.3): World energy consumption, 1990-2040
(Source: EIA, 2013)

## 1.4 Energy sector in Gaza Strip.

Before shifting the focus to energy management practices in Palestinian construction industry, some general energy statistics regarding energy consumption in Palestine will be presented briefly.

### 1.4.1 Energy supply

Energy production and trade are considered as one aspect of the “energy tragedy” in the Palestinian territories, energy consumption is the other. With the exception of the latest discovery of the natural gas reserve on the shore of Gaza and some wood supplies, the Palestinian territories dispose of no energy resources. In general, Palestinian territories relies mostly on Israel for its fossil fuel and electricity imports (Abu Hamed et al., 2012). The vast majority of fossil fuels consumed in the Palestinian territories are imported, with the majority originating in Israel and with marginal percentages from Egypt and Jordan. Fossil fuels are principally consumed by the transportation sector. Figure (1.4) shows the primary energy sources in the Palestinian territories in 2008. The majority, 78%, are liquid fossil fuels, such as gasoline, diesel and liquefied petroleum gas, while the remaining 22% is renewable energy sources. Diesel and gasoline account for 79% of the fossil fuels consumed in the Palestinian territories. There is no consumption of solid fossil fuels in the Palestinian territories. About 56% of renewable energy produced in the Palestinian territories is solar energy from solar water heaters and 43% is biomass from wood, olive cake and charcoal. The biomass is mainly used for heating purposes. The only domestic production of traditional power takes place at the Gaza power plant, which has struggled to operate at more than half capacity since 2006 and especially since 2009 when the Israeli Air Force attacked it and when European Union funding of fuel shipments ceased (PCBS, 2009a).

Gaza Strip considered as a special case of Palestinian territories, its energy sources consist of the energy generated by petroleum and natural gas derivatives; electricity and renewable energy (including solar power, and energy generated from burning wood, peat, etc.). Petroleum derivatives comprises 51% of the total locally energy consumed. Approximately 31% and 18% of the total locally energy consumed are electricity and renewable energy (generated by solar power), respectively (MoPAD, 2009). In addition, Gaza strip is rich in solar energy, which is abundant during the entire year as a result of the territory's location near the hot dry region of the world. It is believed that solar energy can be used in different applications in buildings, which may contribute to overcome the energy problems, especially in the residential sector, currently facing Gaza (Muhaisen and Ahlbäck, 2012). Renewable energy is generated by solar power (temperature), used for heating water in residential buildings. Exploitation of renewable energy sources comprises approximately 18% of the total energy consumption in Palestine. Annual growth of the solar power use is almost 1%. The use of renewable energy, especially solar power, is very low in comparison to available capacities (Elaydi et al., 2012). On other hand, electricity sector is a significant component of civil and industrial development as well as economic growth. It is known that there is a shortage of about 40% of the electrical energy needed by Gaza. However, electricity in Gaza Strip is available from the following sources; (Elaydi et al., 2012)

1. **Importation from Israel:** In 2008, Palestinian dependence on Israel constituted 87.7% of total electricity consumption, including 97.7% in the West Bank and 68.1% in Gaza.

2. **Local generation (Gaza Electricity Generation Plant):** This plant has the capacity to supply only 20% of the combined needs of West Bank and Gaza, but it can supply about two-thirds of the current maximum load on the Gazan electricity system (it is constrained to using 50% of capacity at present because of the limitations of the transmission network to take power from the plant). The plant generates electricity at high cost because it currently uses costly gasoil (World Bank, 2007).

3. **Importation from neighboring countries (Egypt and Jordan)**: In late 2006, the Palestinian Energy Authority (PEA) installed a 22KV medium pressure supply line with a 17MW capacity between the Palestinian Rafah and the Egyptian Rafah cities in order to supply the Palestinian Rafah city with electricity from Egypt.

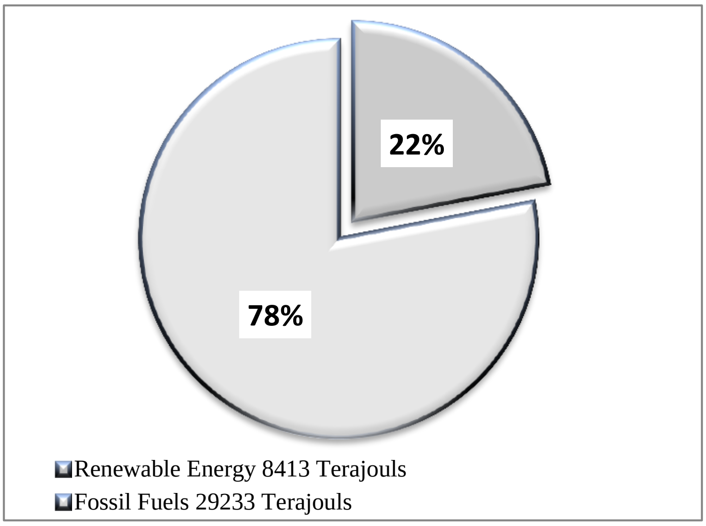


Figure (1.4): Primary energy sources in Palestinian territories in 2008 . (Source: PCBS, 2009a)

### 1.4.2 Energy demand.

Energy consumption per capita of the majority of the population has been considerably increased especially in the developing countries. In developing countries this energy growth has been realized recently due to major developments in several sectors such as residential, industrial and commercial (Ibrik and Mahmoud, 2005).

In the same line, energy demand growth in Palestine results from the population growth, increasing living standard as well as the level of development in all aspects of life (OCHA, 2008). Consumption of electricity in the West Bank grew at 6.4% annually from 1999 to 2005, and in Gaza reportedly grew on average at about 10% annually from 1999 to 2005. Consumption of petroleum products in 2005 was three times the depressed level of 2002, which in turn was about 50% above the level in 1999. Most energy demand (75%) is accounted for by the service and household sectors, since there is relatively little activity in manufacturing (World Bank, 2007). Energy demands in Palestinian industries account for approximately 5 to 6 % of the national energy demand. Construction sector forms 10% of the industrial energy demand (Elaydi et al., 2012). Energy generated by gas and petroleum derivatives including benzene, diesel, liquefied petroleum gas (cooking and heating gas) comprises 51% of total consumption in the local market. A major portion of this energy is used as fuel by vehicles, heating and cooling system, workshops, and factories (Elaydi et al., 2012).

Figure (1.5) provides a clear description about energy use in different sectors in Palestine terr. From this figure it is clear that, the distribution of the total annual energy consumption in different economic activities in the Palestinian territories clearly reveals that the industrial sector consumes the main bulk of energy; about 53% of the total consumption of the economic activities. However, internal trade sector consumes the second biggest amount with an average of 23%, while the construction sector only uses 3% of the total consumption. This indicates that the industrial sector should be the focus of any plan to reduce the economic activities energy demand in Gaza in the future (PCBS, 2009b).

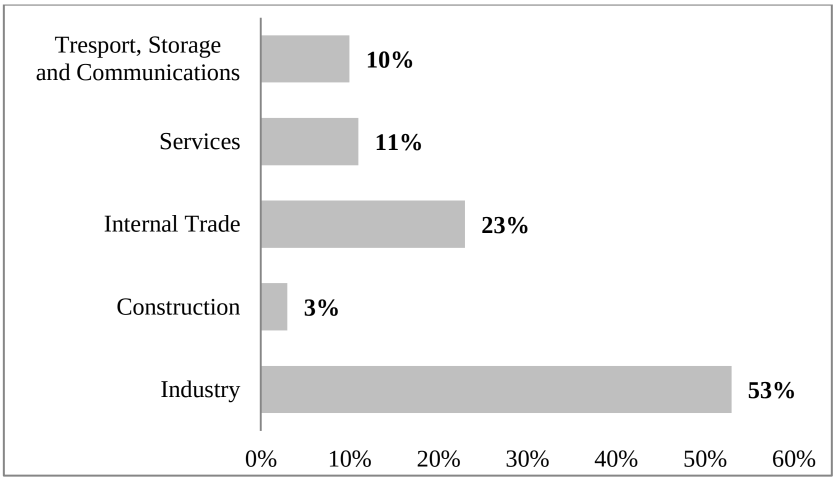

Figure (1.5): Energy consumption in economic activities in the Palestinian territories, 2008. (Source: PCBS, 2009b).

### 1.4.3 Energy sector challenges

Energy remains crucial to economic development in any civilized nation and it should be viewed as any other valuable raw material resource required running a business (Yaseen, 2008). It is important for the existence and development of humankind due to the role of its products in supporting the economy of a country and thereby ensure a steady flow of goods and services to its population (Jiang, 2008; Akinbami and Lawal, 2009). It is known that, without an adequate energy supply and affordable prices of energy products, no modern society or modern civilization would have been possible and development issue in any modern society cannot be seriously addressed (EIA, 2013). From other side, energy consumption used as indicator to the economic situation of the country (PCBS, 2009b). By the amount of energy use, the urbanization level of any country can be reflected. As populations become more urbanized and commercial funds, especially electricity, become easier to obtain, the demand for energy services such as refrigeration, legating, heating, and cooling increases (Akinbami and Lawal, 2009). So that, energy need to be managed well in order to increase the business' profitability and competitiveness and to mitigate the seriousness of these impacts (Yaseen, 2008).

In Palestine, energy is even more important due to the critical situation represented by the country's high population density, lack of natural resources, and unstable political situation (OCHA, 2008). The efficient use of energy and energy conservation in domestic and industrial sectors are not in a better condition than most developing countries (Yaseen, 2008, MoPAD, 2009). Energy security is a main challenge of energy sector in Palestinian territories as a result of the high dependency on Israeli sources for energy (MoPAD, 2012). Gaza Strip is almost totally dependent on the electricity and fossil fuel imported from Israel (Muhaisen and Ahlbäck, 2012). In the same line, Gaza's isolation imposed by Israel presents technical and political challenges for transporting, storing, importing and exporting energy. This dependency and isolation increased the energy prices which are considered as one of the main problems for the Palestinian energy sector. The shortage in supply of conventional energy particularly electricity and petroleum products that are monopolized by the Israeli authority and the lack of a Palestinian infrastructure for close to three decades has impeded any realistic progress on the energy front and created chronic energy problems (MoPAD, 2009). The lack of a stable, reliable and sufficient energy system is one reason that Palestinian community development and economic development are curtailed, even before accounting for anticipated population growth and economic potential. Today, total energy consumption in the Palestinian territories is the lowest in the region, costs more than anywhere else in the region and constitutes a higher proportion of household expenditure (Abu Hamed et al., 2012). Generally, World Bank (2007) listed the major challenges that facing the West Bank and Gaza Strip energy sector as follows:

1. Lack of national energy resources which make the energy sector in Palestinian territories to be almost dependent on imported energy supplies, specifically electricity and oil products. Because of political and logistical factors, nearly all of these supplies at present come from Israel.
2. West Bank and Gaza Strip fragmentation into two distinct geographical zones with divergent economic characteristics causes many difficulties related to energy supply sources and control.
3. The constraints imposed by Israeli policies and actions on the ability of the Palestinian Authority (PA) to operate and develop its energy systems.

It is also expected that Palestinian energy needs will be increased in the next years due to the national development in all sectors. However, such increment will be accompanied with restricted regulations on energy consumption under the energy conservation measures (Ibrik and Mahmoud, 2005). Recent statistical studies on electricity growth and energy demand in Palestine illustrate a sharp increase in electrical energy consumption with an annual average growth of 10 % (Elaydi et al., 2012). A shortage of about 35% of the required electricity caused people to suffer from daily power cuts lasting up to 8 hours in day (PENRA, 2014). Residential sector in Gaza constitutes up to 70% of the total energy needs, while domestic water consumption is at pars with irrigation needs. Conventional construction methods used in Gaza also consume large amounts of energy and materials and generate vast amounts of waste. Combined with the rapid population growth in Gaza, the current approach to construction will inevitably increase demands for these resources to levels that are unsustainable, while further causing degradation to the vulnerable environment in Gaza (Muhaisen and Ahlbäck, 2012).

### 1.4.4 Energy use in construction life cycle

Industrial sector is the largest energy user, accounting for around 31 percent of world energy consumption since the early 1990s (UNIDO, 2011). Diverse industries consumed energy including manufacturing, agriculture, mining, and construction and for a wide range of activities, such as processing and assembly, space conditioning, and lighting (Abdelaziz et al., 2011). Construction industry consumes a significant amount of raw materials and many of which are energy intensive to process and produce. It is estimated that as much as 50 percent of all materials extracted from the earth are transformed into construction materials (UN Global Compact and Accenture, 2012). Even though the total quantity of energy consumed in a building during its lifetime maybe many times than that consumed in its construction, there are number of reasons why the energy use in the construction process should be treated as a matter of importance in looking for ways to minimize energy use in the built environment as a whole (Tiwari, 2001). As one of the industrial sector, construction sector has important role in sustainable development, it is not only due to participation in national economy, but it is due to the fact that constructed environment has great influence on life quality, comfort, security, health, etc. (Zabihi et al., 2012). Moreover, for engineering constructions, use of materials and harmful substances during construction works and maintenance, transport during construction and the use of energy during maintenance have been identified as the most important environmental aspects (Varnas et al., 2009).

The link between the use of energy in buildings and the total energy use is well established and identified as a key component to be addressed by all stakeholders in the construction sector (Na et al., 2012). Construction sector related activities are main contributors of local and regional energy consumption and air pollutants, such as carbon monoxide, lead, sulphur oxides and nitrogen oxide, it accounts for an estimated 40% of all resources consumption (Muhaisen and Ahlbäck, 2012). Buildings alone constitute a significant and rapidly growing energy consuming sector in the developing countries , they are responsible for 25 to 40% of global energy use , 38% of electricity use and 30 to 40% of global greenhouse gases (Jarnehammar et al., 2008; UNEP-SBCI, 2009; Akinbami and Lawal, 2009; Chang and Ries, 2011). Energy and environmental resources can be consumed during all life cycle stages of the construction project including the resources needed for the extraction, processing and transportation of raw materials, construction, use and demolition (Morel et al., 2001; Ko, 2010; Dixit et al., 2012). During its operation, a construction project consumes a vast amount of energy and environmental resources and at the end of a construction project's life cycle the demolition activities generate a large volume of various construction wastes. Such generated environmental impacts are common in both developed and developing countries and regions (Suliman and Omran, 2009). However, a high proportion of the energy used in most buildings is used in the production of a small number of key materials, including concrete, mortar and plaster, bricks and blocks, and timber. Life cycle of the building refers to all temporal phases or stages, from the point where construction materials are produced until the building is to be demolished where energy required during every one of these stages (Adalberth, 1997). All energy requirements associated with the building during its life time is called the life cycle energy (Fay et al., 2000). To obtain accurate results from life cycle energy analysis it is important to clarify the form of energy (Karimpour et al., 2014). Figure (1.6) below shows the different phases of the building life cycle.

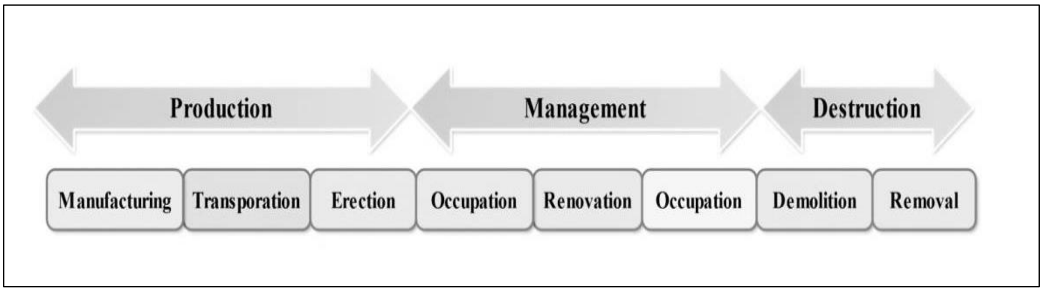


Figure (1.6): The shifting temporal phases of a building during its life cycle.
(Source: Adalberth, 1997)

Fay et al. (2000), Akinbami and Lawal (2009), Verbeeck and Hens (2010), Dixit et al. (2012) and Karimpour et al. (2014) divided the life cycle energy of a building into two types, embodied energy and operation energy. Figure (1.7) illustrates the energy used during each phase of building life cycle. Sorrell et al. (2011) lunched another names for the types of energy consumed in the industrial sector which are commonly known as process and generic. The process energy refers to energy used directly in the production process, whereas the generic energy refers to energy used for non-core applications such as heating, ventilation and air conditioning (HVAC), lighting and information technology. Emissions arising from each one of these energy consumptions known as embodied and operational emissions (Fay et al., 2000).

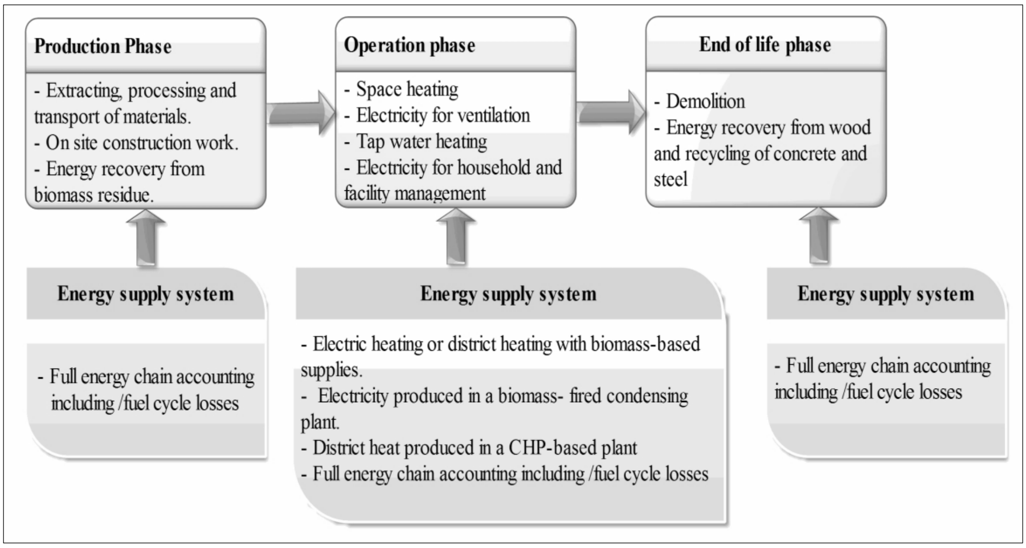


Figure (1.7) : Modeled activities and primary energy flows for buildings
(Source : Dodoo, 2011).

Embodied energy refers to “the total energy required in the creation of a building, including the direct energy used in construction and assembly process, and indirect energy that is required to manufacture the materials and components of the buildings (Crowther, 1999). BEER (2002) defined the embodied energy as “the quantity of energy required by all activities associated with the production process, including the relative proportions consumed in all activities upstream to the acquisition of natural resources and the share of energy used in making equipment and other supporting functions”. It is consumed to extract raw materials, transport and refine them, then use them for manufacturing and assembling new products, transportation of the products, construction at the building site, renovation and demolition of the building (Fay et al., 2000; Akinbami and Lawal, 2009; Dixit et al., 2012). Operation energy refers to “the energy required for maintaining comfort conditions inside buildings, water use and powering appliances, etc.” (Verbeeck and Hens, 2010). It is generally consumed for space cooling and heating, ventilation, lighting, hot water, and running electrical equipment in the dwelling (Fay et al., 2000; Akinbami and Lawal, 2009; Dixit et al., 2010; Dixit et al., 2012).

Current interpretations of embodied energy are quite unclear and vary greatly and its databases suffer from the problems of variation and incomparability. Parameters differ and cause significant variation in reported embodied energy figures (Dixit et al., 2012). For example, UNEP-SBCI (2009) pinpointed five phases of the energy consumption in modern buildings, in which the embodied energy considered as one phase of these five phases as follows:

1. **The first phase (embodied energy):** corresponds to the manufacturing of building materials and components;
2. **The second phase (grey energy)**: correspond to the energy used to transport the building materials from production plants to the building site;
3. **The third phase (induced energy ) :** includes the energy used in the actual construction of the building;
4. **The fourth phase (operational energy) :** which is the energy corresponds to the running of the building when it is occupied;
5. **The fifth phase:** energy is consumed in the demolition process of buildings as well as in the recycling of their parts, when this is promoted.

(Adalberth, 1997; Dixit et al., 2010; Dixit et al., 2012) reported that embodied energy includes more than one phase except operation phase, and postulated that it has two primary components, direct energy and indirect energy. Direct energy is "the energy consumed in onsite and offsite operations, such as construction, prefabrication, assembly, transportation and administration. Indirect energy is "the energy consumed in manufacturing the building materials, in renovation, refurbishment and demolition processes of the buildings" and it includes three elements, as follows:

1. **Initial embodied energy:** is consumed during extraction of the raw material the procurement, production ion and transportation of semi-manufactured components and finished product delivery (transportation) to the construction site.
2. **Recurrent embodied energy:** is used in various maintenance and refurbishment processes during the useful life of a building.
3. **Demolition energy:** is expended in the processes of a building's deconstruction and disposal of building materials

Despite the growing significance of embodied energy inherent in building and its relationship to carbon emissions, buildings embodied energy is a relatively small factor of life cycle energy and can generally be ignored when compared with operation energy (Dixit et al., 2012; Davies et al., 2013a; Karimpour et al., 2014). It only accounts for one-third to one-fourth of the energy consumption during 30 years of use of a building and substantial emissions implications arising from each one of these energy consumptions (BEER, 2002; Verbeeck and Hens, 2010). Yaseen (2008) stated that embodied energy of a building has been estimated to make up between 6 per cent and 25 per cent of the total energy consumption for a building over 50 years. After reviewing 60 case studies from past literature Sartori and Hestnes (2007) concluded that for a conventional building, the embodied energy could account for 2 to 38 percent of the total life cycle energy, whereas, for a low energy building this range could be 9 to 46 percent. Thormark (2007) asserted that embodied energy of a low energy house could be equal 40 to 60 percent of total life cycle energy. Worldwide, embodied emissions account for about 13 to 18 percent of the total carbon footprint of any construction project (UNEP-SBCI, 2009). So that, to date, major research has mainly focused on the energy use for buildings during their period of use including space heating, hot water and the need for electricity (Adalberth, 1997).

Identically, buildings emit more $CO_2$ and consume more energy globally than any other sector (Sheffer and Levitt, 2010). These emissions primarily arise from consumption of fossil fuel based energy during all phases of building life cycle, both through the direct use of fossil fuels and through the use of electricity which has been generated from fossil fuels (UNEP-SBCI, 2009). In developing countries the proportion of the construction industry on the total energy consumption and GHG emissions is much higher than in developed countries due to the rapid economic growth and fast urbanization, which increases the energy production and usage. Also, population growth in these countries induces the problem of pollution and waste generation, which produces $CO_2$ emissions in the atmosphere (Saravanan, 2011). Construction of buildings provides the opportunity to contribute to a reduction in environmental impacts by decreasing $CO_2$ emissions through reduced energy consumption (Wyk et al., 2011).

There are thus good environmental reasons for seeking to reduce the energy in buildings (Tiwari, 2001). So that, construction practitioners worldwide are beginning to appreciate sustainability and acknowledge the advantages of sustainable building (Abidin, 2009; Dixit et al., 2012). Generally, contractor is responsible for pre-construction (i.e. selecting construction methods) and construction activities (i.e. installation of building materials and services (Li et al, 2010). Energy consumed during these phases of particular interest for a contractor, which involve the initial embodied energy of the building life cycle energy consumed up to the project completion for material (i.e. procurement of raw materials), transportation (i.e. transport of project resources such as materials, plant and equipment, and operatives), and construction (i.e. assembly) (Davies et al. 2013a).

### 1.4.5 Energy use during project construction.

Construction can be interpreted at four levels: as site activity, the comprehensive project cycle, everything related to the business of construction and the broader process of human settlement creation. The most common interpretation is as site activities that lead to the realization of a specific building or other construction project. At this simplest level construction is viewed as a specific stage in the project cycle (Alsubeh, 2013). As one component of the embodied energy, construction energy forms one aspect of project direct energy and relates to the energy consumed during the installation of materials up to project practical completion and represents the largest share of construction process CO2 emissions (Davies et al., 2013b). In addition, during project construction, contractor use energy whenever construction materials are to be moved from one place to another, transportation of the material from the manufacturer to the building site and the energy needed for a variety of process during erecting the building such as electricity for lighting purposes and for machinery, instance drying and drainage and so on (Adalberth, 1997). However, construction phase which is one of the important phases of construction projects production accounts for around 5-10 % of total energy consumption during their production processes (UNEP-SBCI, 2009). $CO_2$ emission as a result of energy used during construction activities also highly considered, which can be broken down further as direct emissions (which are from the burning of fuel) and indirect emissions from the use of electricity from grid supply, and other indirect emissions from the use of company vehicles, business travels and wastages (Saravanan, 2011).

Previous studies have shown that onsite construction can represent up to 7% of project life cycle energy, depending upon building type and lifespan (Davies et al., 2013b). UNCHS (1991) indicated that construction activity accounts for a small but important proportion of the embodied energy in buildings, ranging from about 15 to 35 per cent of the embodied energy. Embodied energy is dominated by building material manufacturing, representing 90%, with the share of transportation and construction 4% and 6% respectively (Chang and Ries, 2011). A large part of the energy use in construction process is related to the use of mechanical plant for transporting, leveling, digging, lifting, compacting and mixing, while a second significant component relates to the energy use in the buildings, both temporary and permanent, used by the builder for the construction activity. Energy embodied in materials used for temporary works, scaffolding and formwork for concrete, for example, forms a third component (UNCHS, 1991).

In general, energy required in the construction process can be divided into two main categories, fossil fuel and electricity. Fuel is used in transport and in the equipment onsite, mostly as diesel. With the transport of people, petrol is also used. On the construction site the quantity of diesel and electricity used, depends on many factors such as the type of project, the size of the project, the availability of electricity and construction method (Gorkum, 2010). The major fuel used on construction sites is diesel for construction plants were estimated to be 75% to 80% of the fuel used on site. Electricity can be supplied from temporary main supplies and mostly from diesel generators. When the numbers and types of the plant equipment are taken into account, these electrical consumption figures represent only 20% to 25% of the total energy consumed on construction site. The major energy users on site are construction plants such as backhoe loaders; dampers; hydraulic excavators; cranes; etc. (Ndayiragije, 2006). In the same line, Yan et al., (2010) carried out a case study on carbon emissions as a result of the energy consumed on site for the building construction period for a building in Hong Kong, in which four sources of carbon emissions were included (Figure 1.8) such as manufacture and transportation of building materials, energy consumption of construction equipment, energy consumption for processing resources, and disposal of construction waste.

Intervention at this level is limited to those aspects under the direct control of the contractor. During on site construction, contractor often has a power over choices regarding the adoption of different technologies and equipment (Berardi, 2013). When deciding on a construction method in a project, the deciding factors are mostly; constructability, construction time, location, available resources and financial aspects.

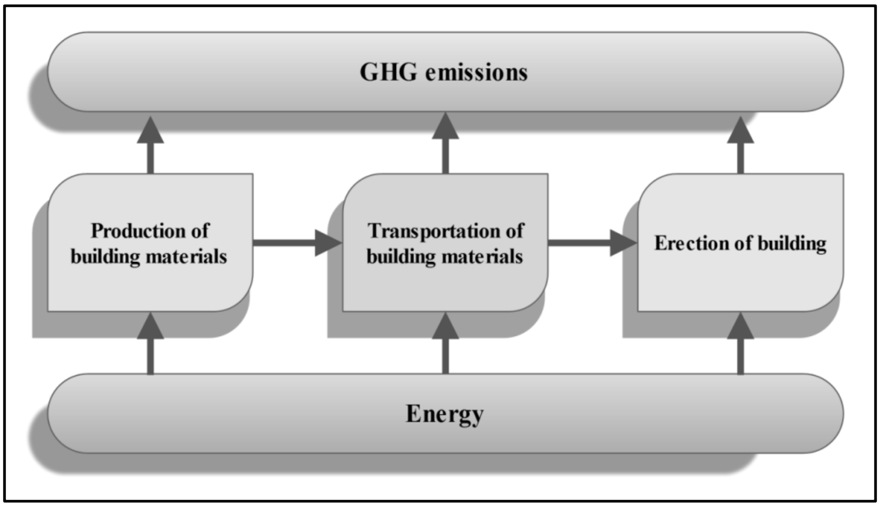


Figure (1.8): GHG emissions as a result of the energy used during on site construction of building (Source: Yan et al., 2010)

The amount of energy used for each construction method and the specific $CO_2$ emissions, are not factors of great importance in this matter (Gorkum, 2010). Recently, many contractors have a vested interest within embodied energy performance due to their significant involvement within project procurement, pre-construction and on site construction activities (Davies et al. 2013a). They are deemed responsible for the consumption and management of this energy and the wider project environmental performance by capturing, verifying and reporting data (Davies et al., 2013b). They play an important role in promoting sustainable development within the context of the construction industry by assuming the responsibility to minimize their negative impact on environment and society and maximize their economic contribution ( SCTG,2000 ; Tan et al., 2011).

Energy-saving building technologies offer the best available opportunity to reduce GHG emissions with positive net present value and rapid payback. In particular interest of a contractor, energy saving strategies target initial embodied energy to reduce energy use during material (i.e. procurement of raw materials), transportation (i.e. transport of project resources such as materials, plant and equipment, and operatives), and construction (i.e. onsite assembly) life cycle phases up to project practical completion (Davies et al. 2013a). New construction provides the greatest opportunity for adoption of new technologies and best practice in energy efficiency. With the technologies that exist today, energy use could be lowered by 25 to 30 percent by 2030.This has created a tremendous opportunity to reduce energy use and attendant greenhouse gas emissions (Sheffer and Levitt, 2010). However, very little progress has been made in implementing them.

## 1.5 Problem background

Energy is essential in daily life and the issue of energy concerns all people around the world Huge amount of energy needed for countries with faster economic growth. Energy is thus a crucial factor for economic competitiveness and employment. However, global population and energy needs are increased hand-in-hand (Abdelaziz et al., 2011). Several concerns face the world nowadays in the field of energy and its related environmental impacts, especially $CO_2$ emissions. Since the oil crisis of 1973 in particular, the world has been faced with the fact that energy raw materials are exhaustible and the quantity of these raw materials is dwindling. In addition to rapidly growing energy consumption, inconstant and mostly rising energy prices have been also a point (Ates and Durakbasa, 2012).

Gaza Strip shares a great deal of these concerns considering its limited resources. The energy situation in Gaza Strip is far more severe because the reliance on outside, especially Israel for most electricity and petroleum products which make frequent shortage and high price of energy products. This limited resources and reliance on outside leads to minimal economic development and the majority of its population has experienced blackouts for two-thirds of the day (Abu Hamed et al., 2012; Muhaisen and Ahlbäck, 2012). There are a number of large scale construction projects being implemented currently and more are needed in the future to fulfill the continuous growth in energy demands as a result of the rapid increase in Gaza population growth and the development of the number of the constructions projects. As the scale of the construction projects grows, environmental consequences and energy consumption become increasingly significant.

As mentioned earlier, construction projects has a very important impact on the environment, and the process of manufacturing and transporting of building materials, and installing and constructing of buildings consumes great energy and emits large quantity of GHG. Although studies have been done on energy use and GHG emissions in the life cycle of buildings, very few have focused on the construction stage in particular and none comprehensively (Yan et al., 2010). Energy, labor and materials are the three top operating expenses for construction projects. In addition, energy will be needed for a variety of processes, for transportation of the construction materials, tools and equipment from one place to another, for instance drying, drainage and heating, fuels for generators and equipment, electricity for lighting purposes and for machinery, and so on. Energy use will affect the final project cost and using fossil fuel has adverse impacts on the environment and human health through emissions of greenhouse gases and local air pollutants. When relating the manageability of the cost or potential cost savings in each of the above components, energy would lead to a good cost saving, and thus energy management function constitutes a strategic area for cost reduction and environment protection.

Construction contracting is considered the core for construction sector in Palestine. Palestinian contractors have proved their national role and outstanding ability in construction and reconstruction. Moreover, contractors are increasingly leading the construction process through working with clients and designers earlier in the construction process. They are significantly responsible for the use of energy during all construction activities including procurement, monitoring, coordination and overall site management. Eventually, efficient energy use and management and environmental impacts reduction of construction projects are not in a better condition in Gaza Strip. This is a result of a considerable lack of the local contractor's awareness related to energy and environmental issues, importance and benefits during all activities of a construction project. The presence of inaccurate or insufficient information and insufficient energy conservation or management practices related to construction activities make the local contractors carelessness about energy saving. Traditionally, local construction industry has operated on a model of 'lowest bid wins' in the tendering process and contractors rarely involve their energy saving and environment protection procedures in their tender. From other side, rareness of governmental and institutional regulations and support for energy saving and environmental protection in construction industry lead to less participation in energy conservation and environment protection efforts during construction phase. Another reason for problem occurred because no previous research was carried in Gaza Strip to assess the awareness, drivers and barriers to energy management in local construction sector and hence exist a knowledge gap where energy management in construction is still at the infancy stage. Thus, lack of previous researches to evaluate about energy management in construction industry in Gaza Strip can lead to lack of energy saving initiatives among construction industry stakeholders, especially contracting companies.

In summary, energy management can be achieved by increasing awareness and optimizing energy using methods and procedures so as to reduce energy requirements while holding constant or reducing total costs of producing the project. Therefore, this research is intended to provide initial guidance for refining or accelerating the development of energy management and saving programs in Gaza Strip construction sectors. In addition, this research are developed to reduce the knowledge and application gap related to energy issues

## 1.6 Research importance

Link between energy production and use and the local and global environment is causing increasing concern worldwide. In addition, the link between the use of energy during project construction and the total energy use is well studied. Effective energy management and rational use of energy are primary conditions for local economic development through facing frequent energy shortage and losses. Local contractors' realization of the importance of the energy costs and the influences of their activities on the environment are considered the first step to adopt energy management procedures.  There are thus good environmental reasons for seeking to reduce the energy in construction projects.

Novelty of this research is that it was based on the study of leading contracting organizations in Gaza Strip and offers new knowledge and insight into the management of knowledge in relation to energy management within one of the largest local economic sector by offering the basic tools and guidelines of proper energy management for local contractors which can enhance them to adopt energy saving techniques to improve their economic competition. In fact, social responsibility of construction sector can be established through adopting energy saving procedures.

## 1.7 Research aim and objectives

Overall aim of this thesis is to investigate and create an understanding of how energy issues are managed in local construction in order to contribute to develop energy efficient on-site construction process in Gaza Strip

To achieve this aim, five different objectives have been proposed, which are:

1- To assess the local contractors level of awareness about energy issues and energy management in construction industry.

2- To identify the degree of practice of energy saving and management during construction process in local contracting firms.

3- To explore the major drivers enhancing the local contractors to adopt energy management during project construction.

4- To identify the key barriers to the implementation of energy management in local contracting companies during the project construction.

5- To pinpoint the contractor best activities to reduce energy consumption during the project construction .

In addition, to develop an appropriate conclusion it is important to determine the starting point. So, it is useful to ask questions about energy management issue in contracting organization working in Gaza Strip. This research will try to answer about these questions, including:

1) What are the current levels of awareness of energy management in local contracting companies?

2) What are the current levels of application of energy management in local contracting companies?

3) How to motivate local contractors to adopt energy management in their construction projects?

4) What are the barriers that prohibiting local contractor to adopt energy management in their construction activities?

5) What are the best ways to save energy during project construction?

## 1.8 Research benefits

Outcomes of this research are expected to provide a better understanding of the potential benefits of integrating an energy management standard as well as the barriers to adopt it for all parties in Gaza Strip. Scientific data can be provided for local policy makers, standards authorities and construction associations in adopting, implementing and supporting an energy management and to aid in the design of their energy management programs, development policies and plans for construction industry. Local contractors can benefit from addressing energy saving provision in their organizations to achieve competitive advantage, and to get realistic tender prices. Furthmore, the contribution of construction industry in the economy can be maintained and improved through:

1) Reducing construction costs by saving energy.
2) Saving environment by reducing Co2 emissions as a result of energy conservation.
3) Focusing on increasing profitability through:
    I. Efficient use and management of construction resources.
    II. Adopting modern methods and technologies for construction activities.

## 1.9 Research scope and limitations:

This research investigated the local contractors' level of awareness and knowledge of energy management principles during project construction in Gaza Strip. It focused on the drivers, and barriers to adopt energy management during project construction, and from the contractors' point of view. In addition, this research investigates the best activities to save energy during project construction. Body of work within the research focused on the Palestinian contractors working in Gaza Strip; who were registered and classified in Palestinian Contractors Union (PCU) in Gaza Strip for the year 2012 – 2013 as first, second and third class in the fields of: building, infrastructure, electromechanical, roads and others.

## 1.10 Research methodology

This research objectives are achieved through the following methods:

I. **Desk study (Literature review):** Literature reviewed on energy management and efficiency, sustainable construction, green construction and related environmental management issues in construction projects. A comprehensive overview was conducted to identify the major drivers, barriers and activities to adopt energy management principles. Collected data in this phase were refined and investigated by different experts and then used in designing the questionnaire used in the study.

II. **Questionnaires survey:** Questionnaire was used in this research based on both a literature survey and previous research in this field; also it included the comments obtained by the conducted reviews with several experts that are in the line with energy management concept. Each section in the questionnaire was structured to attain one objective of the study, including identifying the level of awareness, practice, major drivers, barriers and activities of energy management.

Questionnaire pretesting considered an efficient and effective way to improve the collection and organizing of the data. Before the main survey was launched, a pretesting process was conducted to ensure the clarity and relevance of the questions. This process involved academic, professionals and decision makers from major contracting firms in Gaza Strip. The respondents to study questionnaire were in decision making positions, including projects managers, and site engineers.

### III. Analysis, conclusion and recommendations

The outcomes of the study were analyzed and evaluated through the use of the Statistical Package for Social Science (SPSS) software. Analysis data were collected, studied and compared with other studies to produce brief conclusions and applicable recommendations.

## 1.11 Thesis structure

This thesis study report consists of following parts:

- **Chapter 1: Introduction**

This chapter provides an introduction to the research problem and outlines the aim and objectives along with importance of the research for the local contracting organizational. The research scope and limitations, and the thesis structure, outline contents are also presented in this chapter.

- **Chapter 2: Literature review**

This chapter provides a review of existing researches in the subject area and highlighting gaps in existing knowledge. The main topics presented in this chapter are: energy use in construction, sustainability, drivers, barriers and strategies to adopt energy management in local construction contracting organizations.

- **Chapter 3: Methodology**

This chapter reviews a number of research methodological considerations and justifies the selection of each method used in the research project.

- **Chapter 4: Results and discussion**

This chapter provides a detailed description of the research results and any comments or details related to these results.

- **Chapter 5 Conclusions and Recommendations**

This chapter presents the findings of the research, identifies the impacts and implications on the contracting organizations and on the wider construction industry, and formulates final conclusions, including the critical evaluation of the research, along with recommendations for future research.

- **References**

This part presents a list of references used as part of the main body of research.

- **Appendices**

This part presents the appendices. Copies of used questionnaire survey and any important tables or information used in the study were included in this part.

Chapter 2

# Literature review

## 2.1 Sustainability and sustainable construction.

In recent years, there has been an increasing awareness and interest in sustainability in construction industry, especially in developing countries (Khalfan et al., 2002; Zabihi et al., 2012). Development that is happening shows that sustainability and sustainable construction are not yet an integral part of construction industry decision making and business practice. In fact, sustainability is still seen as a "nice-to-have" addition to normal practice, and not as the main motivator that drives all business and development decisions (Plessis, 2002). A very commonly used definition of sustainability is implied in the following definition of sustainable development which is found in the report of the Brundtland commission of the United Nations (WCED, 1987). Sustainable development is “development that meets the needs of the present without compromising the ability of future generations to meet their own needs”. In construction practice, sustainable construction refers to the different methods used in construction project which bring less harm to the environment, benefit the society and increase profit of the company (Shen et al., 2012). Generally, the responsibility of the construction industry towards sustainable development appears by applying sustainable practices in construction activities (Baloi,2003). Today, construction clients are increasingly requiring business consultants, contractors and suppliers to adopt sustainable policies in construction process (Ochieng et al.,2014).\

Sustainable construction covers the comprehensive construction cycle from the extraction of raw materials, through the planning, design and construction of buildings and infrastructure, until their final deconstruction and management of the resultant waste (Tan et al., 2011). Building Energy Efficiency Research “BEER” (2002) defined sustainable construction as "the creation and responsible management of a healthy built environment based on resource efficient and ecological principles". Another definition of sustainable construction introduced by Plessis (2002) which is “a holistic process aiming to restore and maintain harmony between the natural and built environments, and create settlements that affirm human dignity and encourage economic equity”. Tan et al. (2011) stated that sustainable construction refers to “the integration of environmental, social and economic considerations into construction business strategies and practices”.

Sustainable construction can benefit the society and their users by consuming fewer resources in construction and operation through conservation of energy, water and natural resources by reuse, recycling, innovative design and the minimization of waste and pollution which providing healthier working and living environments (Suliman and Omran, 2009;Abdul Azis et al., 2012). A study conducted by Baloi (2003) demonstrated that sustainable construction practices can contribute up to 15% of cost saving and 18.61% of the $CO_2$ emission reduction and concludes that sustainable construction practices not only lead to the cost effectiveness but also significant reduction can be made in carbon emissions. Other benefits that accrue from the adoption of sustainable construction practices in construction industry include compliance with the environmental legislation and regulations (avoid liabilities), contribution to the environmental protection, improvement of staff working conditions (Baloi, 2003). Suliman and Omran (2009) stated that sustainable construction is a set of processes by which a profitable and competitive industry delivers built assets (buildings, structures, supporting infrastructure and their immediate surroundings) that:

- Enhance the quality of life and offer customer satisfaction;
- Offer flexibility and the potential to cater for user changes in the future;
- Provide and support desirable natural and social environments; and
- Maximize the efficient use of resources.

In the same line, Khalfan et al. (2002) encapsulated the six key features and requirements of sustainability as following:

1. Minimization of resource consumption;
2. Maximization of resource reuse;
3. Use renewable and recyclable resources;
4. Protect the natural environment;
5. Create a healthy and non-toxic environment;
6. Pursue quality in creating the built environment.

Additionally, Organization for Economic Cooperation and Development (OECD) has identified five objectives for sustainable buildings which are: (OECD, 2013)

1. Resource efficiency;
2. Energy efficiency (including greenhouse gas emissions reduction);
3. Pollution prevention (including indoor air quality and noise abatement);
4. Harmonization with environment (including environmental assessment);
5. Integrated and systemic approaches (including environmental management system).

Sustainable construction embraces three main dimensions namely social, economic and environmental in contrast with the traditional perspective, where the main concerns were economy, utility, and durability (WCED, 1987; BEER, 2002; Baloi, 2003; Šaparauskas and Turskis, 2006; Abidin, 2009; Saravanan, 2011). These aspects described by the previous researchers as follows:

- **Economic dimension:** addresses economics issues such as employment creation, competitiveness enhancement, lower operating/maintenance costs, employment creation, high quality of working environment leading to greater productivity and many others. The economic sustainability is concerned with the micro and macroeconomic benefit. Micro economic focuses on the factors or activities which could lead to monetary gains from the construction while macroeconomic relates to the advantages gained by the public and government from the project success.

- **Environmental dimension:** refers to the activities within the construction project itself, which may, if not handled effectively, have a serious adverse impact on the environment. It deals with the design, construction, operation/maintenance and deconstruction approaches that minimize the adverse impacts on the environment such as air emissions, waste discharges, use of water resources, land use, and others.

- **Social dimension:** social well-being concerns with the benefits of the workers and the future users. It addresses issues pertaining to the enhancement of people's quality of life. Social aspects responding to the needs of people at whatever stage of involvement in the construction process (from commissioning to demolition)

The promotion of sustainable construction practice is to pursue a balance among economic, social, and environmental performance in implementing construction projects (Ekundayo et al., 2011). Abdul Azis et al. (2012) argued that the balance between basic principles of sustainability i.e. environment, economic and social aspect is very important. To achieve this balance, the vision of sustainable construction must change in adoption of dynamic nature of the sustainability concept. In addition it requires decision makers to be flexible and willing to modify their approaches. However, Zabihi et al. (2012) added technical dimension as an additional issue to the mentioned issues considered by many others, four groups of the sustainability aspects in the building and construction considered including environmental, social, economic and technical issues, as described in Figure (2.1) below.

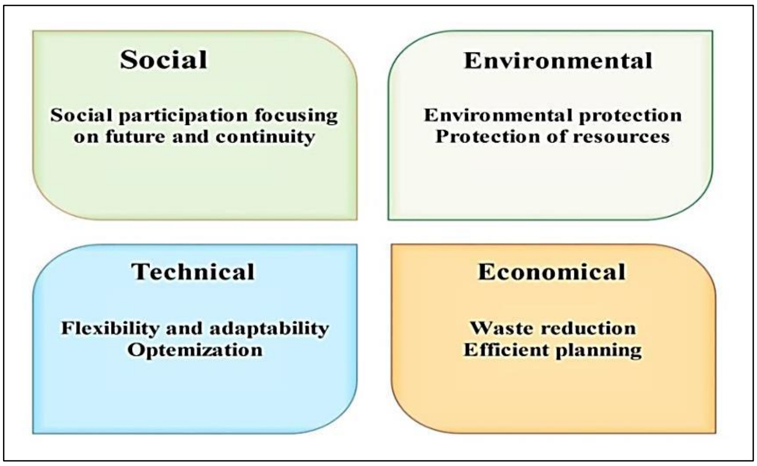


Figure (2.1): Main issues in sustainability
(Source: Zabihi et al., 2012)

Recent researches and growth of knowledge about sustainable development have increased interest in sustainable development terminology. Terminology in the field of sustainable development is becoming increasingly important because the number of terms continues to increase along with the rapid increase in awareness of the importance of sustainability (Glavič and Lukman, 2007). According to Ekundayo et al. (2011), sustainability is a broad meaning and it has been subjected to a range of interpretations. They further suggest that different the definitions of sustainable development imply that application of related term depends on their designation and recognition in different disciplines. So that, several terms related to sustainability are in common use in scientific papers, monographs, textbooks, annual reports of companies, governmental policy usage, and the media. In reality, it is so overused that it has given birth to new terminologies, with words such as cleaner production, pollution prevention, pollution control, minimization of resource usage, green washing, green supply chain management and green buildings, etc., (Ekundayo et al., 2011; Khalfan et al., 2015). For example, environmental innovation as one aspect of sustainability issue can be defined as the use of production equipment, techniques and procedures, and products and product delivery mechanisms that are sustainable (Dewick and M. Miozzo, 2002). Christoffersen et al. (2006) pointed out that, energy management and environmental management are normally integrated.

Green construction is another terminology lunched for sustainable construction and has the same meaning (Abidin, 2009). Building construction companies from various regions around the world have integrated green concept into their construction plans to mitigate the environmental impacts (Hwang and Tan, 2012). Shi et al. (2013) defined green construction as "the premise of ensuring quality, safety and other basic requirements, scientific management and technological progress should be used in engineering construction, to maximize the conservation of resources and reduce the construction activities which will bring negative impacts on the environmental, and to achieve the goal of four savings (energy, land, water and materials) and environmental protection". Green technology also known as environmental or sustainable technology, which consists of a subset of green living and refers to various sciences whose aim is to advance technology to help conserve and protect the environment, such as recycling or renewable energy (Wyk et al., 2011). Green management have received close concern from many countries, construction must adopt measures in the whole process to reduce environmental pollutions and save resources, including energy, land, water and materials (Na et al., 2012). Muhaisen and Ahlbäck (2012) argued that greening the construction sector is considered an effective strategy to advance a development path that promotes job creation and decent work while at the same time safeguarding environmental sustainability in Gaza. BEER (2002) divided the basic measures for green buildings into four areas:

1. Reducing energy in use;
2. Minimizing external pollution and environmental damage;
3. Reducing embodied energy and resource depletion;
4. Minimizing internal pollution and damage to health.

However, resource flow management considered as the basic aspect of sustainability concept in building construction as the reduced consumption of energy and resources (Saravanan, 2011). For buildings, the main environmental aspect is often energy consumption in the finished building, followed by the use of materials and harmful substances. For civil engineering constructions, use of materials and harmful substances during construction works and maintenance, transport during construction and the use of energy during maintenance have been identified as the most important environmental aspects (Varnas et al., 2009). Final energy consumption and energy intensity in construction were suggested by Šaparauskas and Turskis (2006) as the basic indictors to reflect country's construction sustainability.

Natural environment with emphasis on technical issues such as materials, building components, construction technologies and energy related design concepts can be employed to reduce energy use impacts. Recently, an appreciation of the significance of non-technical issues has grown, giving recognition to economic and social sustainability concerns as well as cultural heritage of the built environment as equally important (Shafii et al., 2006; Abidin, 2009). Moreover, energy management can be part of an overall plan for sustainable corporate development. Sustainable energy management can be viewed as the process of managing the energy consumption in the organization to assure that energy has been efficiently consumed (Abu Bakar et al., 2013). It represents a significant opportunity for organizations to reduce their energy use while maintaining or boosting productivity (GSEP-EMWG, 2013). In depth discussions about energy management are provided in the following sections.

## 2.2 Energy management definitions and benefits.

Perception and interpretation of building's sustainable development have been changed in recent years. At first the important point was emphasis on resources limitation namely energy and the method for reduction of its impact on natural environment by minimizing carbon emissions (Zabihi et al., 2012; Vesma, 2012). The reduction of greenhouse gases in the building construction sector is based on principles, which have to be appreciated during all activities concerning the entire building process (Saravanan, 2011). In the face of increasing demand for energy in all sectors, more efficient use of energy has to be considered as one of the major options to achieve sustainable development in the 21st Century (Akinbami and Lawal, 2009). Since 1970s, energy efficiency and conservation have become one of key component to address energy security. It is also regarded as an effective ways for reduction in GHG emissions from fossil fuel to mitigate climate change as well (Tanaka, 2011).

Various approaches and programs tried to improve the uptake of innovative technologies. A wide array of policies have been used and tested in the industrial sector in industrialized countries, with varying success rates. Under perfect market conditions, energy problems and all additional needs for energy services are provided by the lowest cost measures, whether energy supply increases or energy demand reductions (Worrell and Price, 2001b). Although energy efficiency is a technical topic, the solutions are not all technological. Human factors: attitudes, knowledge, awareness and skills will be a significant energy aspect for most organizations because while it is true that people cause some energy waste, they also hold three keys to improvement: (Vesma, 2012)

1. Changing their behavior;
2. Being vigilant for waste;
3. Suggesting improved working methods or technical innovations.

Energy management is now in the global spotlight, due to the pressing need to save energy and reduce greenhouse gas emissions worldwide. It is inspired by and similar to other management systems such as: environmental management, health and safety management, and quality and production management (Christoffersen et al., 2006). Gorp (2004) noted that there has been increasing interest and activity in the field of energy management over the last several decades. It is practiced to varying degrees by manufacturers throughout industry. However, energy management as a concept still at its development stage within the construction industry. There is some level of confusion and disagreement within the advisory documents, as well as amongst project stakeholders on what energy management means and how it could be implemented within construction project environments. Many definitions exist for energy management, all of which agree on the same objective of achieving the same task for less energy use without sacrificing the quality of the environment and/or products through the employment of capital, technology and management skills. Generally, any activity that improves the use of energy falls under the overall definition of energy management which has a wider scope than just conservation (Al-Homoud, 2000). An energy management system is a collection of processes, procedures, and tools designed to engage staff at all levels within an organization in managing energy use on an ongoing basis (GSEP-EMWG, 2013). Energy management becomes a dynamic process where new ideas and knowledge are generated, which, in turn, produce additional energy efficiency gains (Kannan and Boie, 2003). Abu Bakar et al. (2013) argued that, sustainable energy management can be viewed as the process of managing the energy consumption in the organization to assure that energy has been efficiently consumed.

Energy management can be defined as "the strategy of adjusting and optimizing energy, using systems and procedures so as to reduce energy requirements per unit of output while holding constant or reducing total costs of producing the output from these systems" (APO, 2008). Abdelaziz et al. (2011) stated that " energy management is the strategy of meeting energy demand when and where it is needed". Capehart et al. (2006) provide another definition of energy management as "the continuous, systematic and well-organized audit of energy consumption, aiming at energy cost optimization with respect to energy demands, user characteristics, funding opportunities, financing ability and emission reductions achieved". Energy management definition provided by Carbon Trust (2011) considered as the most comprehensive definition which is " the systematic use of management and technology to improve the energy performance of an organization". Changing how energy is managed by implementing an organization wide energy management program is one of the most successful and cost effective ways to bring about energy efficiency improvements. It is an important tool to help organizations meet the critical objectives for their short term survival and long term success (Turner and Doty, 2009).

Energy management considered as a combination of energy efficiency activities, techniques and management of related processes which result in lower energy cost and $CO_2$ emissions (Kannan and Boie, 2003). It can influence organizational and technical procedures, as well as behavior patterns, in order to reduce the total energy consumption, to use basic and additional materials economically and to continuously improve the energy efficiency in the company (Kahlenborn et al., 2010). In fact, energy management process aims to minimize energy costs/waste without affecting production and quality and to minimize environmental effects (Bureau of Energy Efficiency, 2010; Goldberg et al., 2011). Other desirable objectives of energy management programs include: (Capehart et al. 2006; Kahlenborn et al., 2010; Vesma, 2012);

- ✓ Improving energy efficiency and reducing energy use, thereby reducing costs. Energy management systems adoption can save up to 10 % of the firm energy costs in the initial years after implementation by systematically identifying the weak points in the firm energy consumption and addressing them with basic measures;
- ✓ An efficient energy management is therefore an important element of environment protection as it can contribute considerably to reducing greenhouse gas emissions;
- ✓ Improvement of public image as the company is operating sensibly with respect to energy-efficiency and thus protects the environment and cultivating good communications on energy matters;
- ✓ Sustain organization development as efficient energy management, new energy concepts and innovative energy technologies are key to operating successfully in the market in the coming years and decades;
- ✓ Developing and maintaining effective monitoring, reporting, and management strategies for wise energy usage;
- ✓ Finding new and better ways to increase returns from energy investments through research and development;
- ✓ Developing interest in and dedication to the energy management program from all employees;

Energy efficiency is another term that has quite a narrow meaning in the context of energy management, where it refers to the ratio between useful energy output and energy input (Vesma, 2012). Russell (2005) argued energy efficiency refers to practices and standards set forth in an energy management plan. Despite the high total energy consumption among industrial small and medium-sized enterprises "SMEs", the topic of energy efficiency improvements in SMEs has received very little attention so far. Therefore, construction contractors and subcontractors can have a major impact on the energy efficiency of a building construction and energy management can help to control energy consumption in order to avoid unnecessary expenditure, and save money. It improves cost-effectiveness and working conditions, protect the environment and prolong the useful life of equipment and fuels (Ndayiragije, 2006).

## 2.3 Energy management features and principles

Empirical studies in various industrial and public sectors have illustrated the existence of an energy efficiency gap. Energy as a resource is not being used as efficiently as it could be, and there is a recognized but still untapped reservoir of cost-effective technologies that are not being employed, even though these could substantially improve the energy end-use (Thollander et al., 2013). Yaseen (2008) suggested three critical elements when energy saving is set to be applied which were the awareness of the need, access to solutions and visibility of economic benefits.

In the line with the above discussion, energy saving awareness is so significant. However, most managers still do not pay much attention to the benefits of raising energy awareness. Energy awareness is the first step to achieve energy sustainability and without it, efforts in energy conservation can be difficult and leading to energy wastage (Wai, 2009). Microsoft Encarta Dictionary (2005) define awareness as "knowing something, having knowledge of something because you have observed it or somebody has told you about it, noticing or realizing something, mindful that something exists because you notice it or realize that it is happening, knowledgeable, well-informed about what is going on in the world or about the latest developments in a particular sphere of activities. In this paper, awareness refers to having knowledge or realizing something". Yen and Wai (2010) argued that awareness is the essential foundation for an installation's energy program. It helps to change attitudes, thus encouraging users to seek out ways to save energy and also changes behaviors, making sure that energy users take energy-saving actions and continue to use and maintain energy saving equipment after it has been installed. Energy awareness should be followed by behavioral changes to conserve energy or in other words, complying behavior (Wai et al., 2006).

Companies that have an in-depth knowledge and understanding of their energy use and systems to manage it, have demonstrated increased productivity, better staff engagement, and reputational benefits. This is reflected in their share value and attractiveness to institutional investors. Therefore, it is important to give enough attention to the training and awareness of the energy issue, particularly to building operation and maintenance personnel as well as those involved in the production and/or use of the workplace in the facility (Al-Homoud, 2000). In order to address the problems related to energy use in construction projects, energy management system should be established during the whole process of construction, which is not only the inevitable trend in the existence and development of construction industry, but also the essential requirement of sustainable development. Further, energy management approach can be one answer to reduce energy consumption and meet $CO_2$ emission mitigation obligations (Kannan and Boie, 2003).

Industry's possibilities for using energy more efficiently involve many technical actions implemented under diverse political, economic, business and managerial circumstances. In theory, energy efficiency policies could target each of these elements (Tanaka, 2011). So that, several countries have developed an energy management standards and practices as an effective industrial energy efficiency policy mechanism. Eventually, high environmental standards requirements can minimize energy in construction industry (Saravanan, 2011). The purpose of an energy management standard is to provide guidance for industrial facilities to integrate energy efficiency and system optimization into their daily management practices. Typical features of an energy management standard include: (UNIDO, 2007)

a. A strategic plan that requires measurement, management, and documentation for continuous improvement for energy efficiency;
b. A cross-divisional management team led by an energy coordinator who reports directly to management and is responsible for overseeing the implementation of the strategic plan;
c. Policies and procedures to address all aspects of energy purchase, use, and disposal;
d. Projects to demonstrate continuous improvement in energy efficiency;
e. Creation of an Energy Manual, a living document that evolves over time as additional energy saving projects and policies are undertaken and documented;
f. Identification of key performance indicators, unique to the company, that are tracked to measure progress; and
g. Periodic reporting of progress to management based on these measurements.

Effective energy management however requires the use of tools and methodologies that support the strategic decision making process of selecting energy saving measures, which are viable and environmental friendly (Doukas et al., 2009). Ibrik and M. Mahmoud (2005) argued that implementing of a national project in Palestine aiming at energy efficiency improvement in residential and industrial sectors as well as in public utilities, which include wide range of diversified audits and power measurements, had led to a high potential of energy saving. Measurement and audit results had shown that the total conservation potential in these sectors is around 15% of the total energy consumption. Companies that are successfully managing their energy have several elements in common. Best practice allows an organization to develop a thorough understanding of energy sources, energy use and opportunities for improvement. This includes ways to use energy more efficiently in systems, processes and technologies; how energy is sourced and procured; and investigating alternative sources of energy. Energy management may consist of many measures and activities, for that Christoffersen (2006) proposed minimum requirements for energy management with which the rate of energy management application in industries can be determined. The following energy management activities are indicated as minimum requirements:

1. Metering energy consumption of main production processes (such as motor systems, pump systems, steam and process heat systems);
2. Having a written energy policy;
3. Having an official energy manager;
4. Setting an energy saving target;
5. Having implemented energy efficiency projects.

The following energy management activities were indicated by Ates and Durakbasa (2012), as minimum requirements for effective energy management program:

1. Metering the energy consumption of main production processes.
2. Having a written energy policy.
3. Having an official energy manager.
4. Setting an energy saving target.
5. Having implemented energy efficiency projects.
6. Having a staff awareness program in place to encourage energy conservation and efficiency
7. Procuring energy (electricity, fuel oil, diesel, coal) through competitive bids
8. Having procurement guidelines which explicitly indicate energy efficiency in the company procurement manual as one of the selection criteria for the procurement of goods and services

Abdelaziz et al. (2011) claimed that successful energy management consists of three parts: energy auditing to gain knowledge about energy flows, courses and training to increase and maintain awareness and housekeeping that includes keeping up the operations. Furthermore, to be effective, energy management programs should include four main sections (Kannan and Boie, 2003):

1. Analysis of historical data;
2. Energy audit and accounting;
3. Engineering analysis and investments proposals based on feasibility studies;
4. Personnel training and information.

ClimateWorks-Australia (2013) reported that energy efficiency includes all activities on large industrial sites that reduce the amount of energy used to produce a given amount of output. This includes:

1. Equipment upgrades (including both new and existing technologies.
2. Process design and optimization, e.g. modify a production line so that less input needs to be processed (and therefore less energy is required) to create the same amount of output.
3. Process controls and measurements, e.g. use granular data from sub-metering to identify and correct problems that cause unnecessary energy use.
4. Behavior change and maintenance, e.g. Identify opportunities to switch off machinery when not in use.
5. Preparatory activities that precede the actual energy efficiency benefit, such as energy data collection, business case development and feasibility analyses.

Turner and Doty (2009) identified the following requirements for an energy management:

1. Set up an energy management plan;
2. Establish energy records;

3. Identify outside assistance;
4. Assess future energy needs;
5. Identify financing sources;
6. Make energy recommendations;
7. Implement recommendations;
8. Provide liaison for the energy committee;
9. Plan communication strategies;
10. Evaluate program effectiveness.

The International Organization for Standardization, ISO (2008) clarified the basic elements to be considered by top management when defining and documenting any energy policy, which are:

1. Address all significant energy uses;
2. Be appropriate to the defined scope and boundaries of the energy management system;
3. Be relevant to the nature and scale of energy use;
4. Be consistent with the policies of other management systems. provide the framework for setting goals and targets;
5. Be available to the public;
6. Be documented, implemented and maintained;
7. Understood by those working for or on behalf of the organization;
8. Be regularly reviewed, and updated as needed.

All the components of a comprehensive energy management program were described by Turner and Doty (2009) and depicted in Figure (2.2) below. These components are the organizational structure, a policy, and plans for audits, education, reporting, and strategy. It is hoped that by understanding the fundamentals of managing energy, the energy manager can then adapt a good working program to the existing organizational structure.

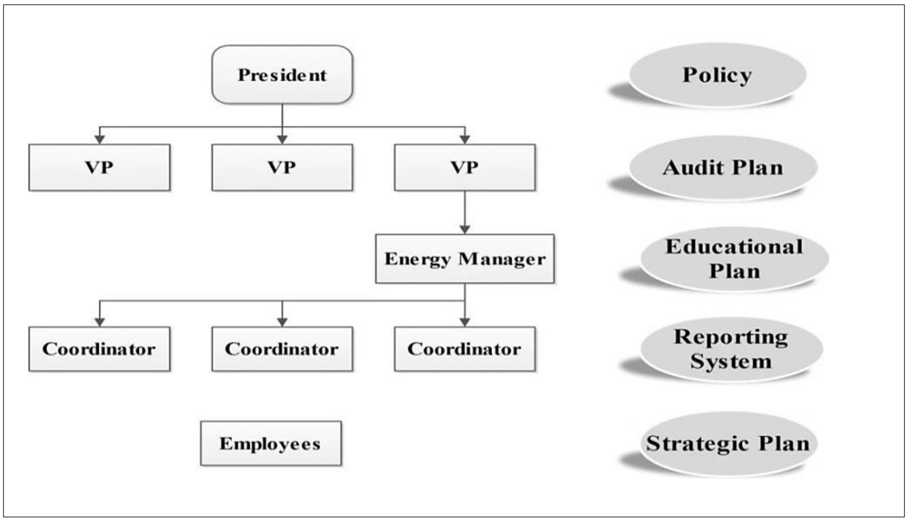


Figure (2.2): Organizational structure and energy management program. (Source: Turner and Doty, 2009).

## 2.4 Drivers to Adopt energy management in construction industry.

In recent years, with global energy consumption increasing and oil prices rising, people have become increasingly worried about the sustainability of the world energy supply (Jiang, 2008). In Palestine, the proceeding toward reducing energy consumption in all energy consuming sectors considered as one of the most imperative, factual, quick and feasible measure to bring down and reduce the problem of energy and reduction in environmental emissions (Yaseen, 2008). However, Rohdin et al. (2007) noted that efficient energy conservation measures are not always implemented although the increased need for industrial energy efficiency. Promoting investments in energy-saving technologies is an important means for achieving environmental goals (De Groot et al., 2001). Thus, every factor that facilitates the implementation of a project and/or increases the returns/reduces the risk of an investment can be considered as a driver (Rohdin et al., 2007). Cagno and Trianni (2013) defined drivers as "factors facilitating the adoption of both energy efficient technologies and practices, thus going beyond the view of investments and including the promotion of an energy-efficient culture and awareness". In addition, these factors can contribute to the development of the company's environmental performance by applying energy management system in the construction industry (Bassioni et al., 2010).

UNIDO (2011) discussed the main benefits gained and drive industrial energy efficiency improvement, including environmental, economic and social benefits that improve energy efficiency for a variety of reasons, including, but not limited to:

- Cost reduction;
- Improved operational reliability and control;
- Improved product quality;
- Reduced waste stream;
- Ability to increase production without requiring additional, and possibly constrained, energy supply;
- Avoidance of capital expenditures through greater utilization of existing equipment assets;
- Recognition as a "green company"; and
- Access to investor capital through demonstration of effective management practices.

Davies et al. (2013a) investigated the key drivers for addressing embodied energy levels within UK non-domestic projects from a contractor's perspective which fall under two groups, the first drivers group is policy and legislative and the second is financial and business group. In the same line, Rettab and Brik (2008) explored the various advantages gained and drive the adoption of a green supply chain approach in the industrial sector in Dubai. Differentiate from competitors, satisfy customers' requirements, improve company brand and establish a competitive advantage are the major benefits indicated. Liu et al. (2012) developed an analytical framework to investigate the major determinant factors for the companies located at Taicang on China to practice energy saving activities. The proposed model includes two sources of driving factors to implement energy saving activities which are external drivers and internal factors introduced in the framework shown in Figure (2.3).

**I. External drivers includes the followings:**

1. Coercive pressure from the organizations with mandatory power;
2. Normative pressure from the industrial associations;
3. Mimetic pressure from the business competitors.

**II. Internal factors include the followings:**

1. A company's energy saving strategy orientation;
2. Top support;
3. A company's learning capacity.

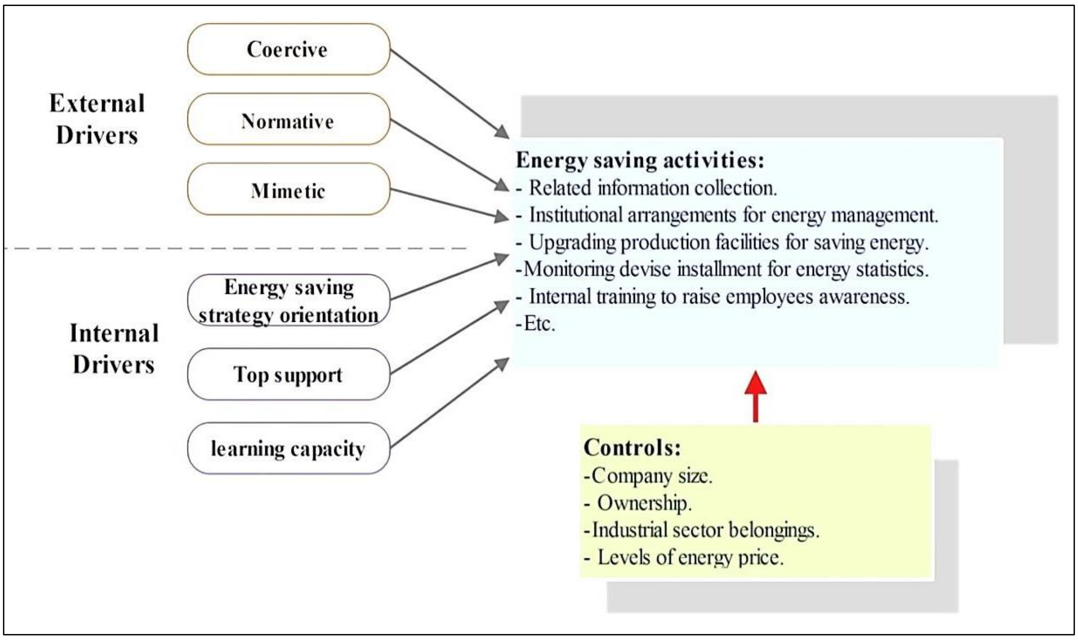


Figure (2.3): Drivers to energy saving at Taicang on China.
(Source: Liu et al., 2012)

Figure (2.4) below describes the result of the study conducted by Christoffersen et al. (2006) which illustrates the motivators to work with energy efficiency in Danish industry. The expected and absolute top motivator is reduction of costs, after this come the environment, image as a green firm, and finally energy management is a natural element in environmental management. Other explanations are demand from customers, enthusiastic employees and suggestion from accountant. Pino et al. (2006) summarized a number of tangible and intangible benefits of sustainable construction as mentioned below:

**A. Tangible benefits:**

1. Cost saving from improved energy management.
2. Cost saving from operation efficiencies.

3. Increased revenues and new markets from providing low-carbon products and services.

**B. Intangible benefits:**

1. Competitive positioning in the market.
2. Improved shareholder relations.
3. Employee-related benefits.

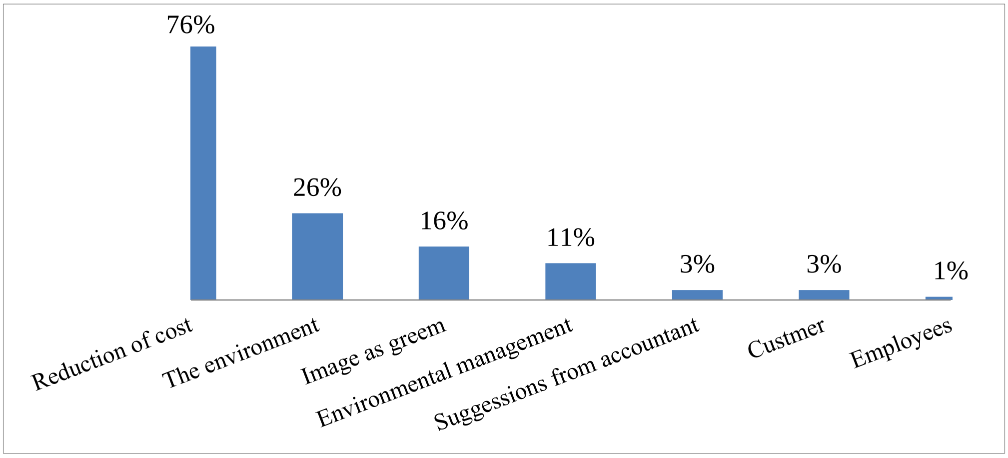


Figure (2.4): Motivators to energy saving in Danish industry.
(Source: Christoffersen et al., 2006)

In general, there are multiple benefits to contractors from implementing energy saving and sustainable practices. With respect to these benefits the drivers of implementing sustainable practices and energy management in construction projects can be grouped under environmental, economic and social aspects.

**I. Environmental drivers :**

These drivers emerged from the major impacts of construction activities on the environment and the benefits gained from reducing these impacts. The exploitation and utilization of energy resources brings about serious ecological and environmental problems which produce emissions that contribute to global warming and acid rain (Baloi, 2003). Scientific observation indicates that the concentration of $CO_2$ in the atmosphere has increased after the industrial revolution and the average temperature of the world has risen by 0.74% over the past century (Jiang, 2008). The development of low-carbon economy is helpful for solving the crisis of global warming and energy security, thus contributing to the global environmental concerns (Chuanzhong and Yingji, 2011; Yaseen, 2008). Additionally, building sector has the largest potential for significantly reducing greenhouse gas emissions compared to other major emitting sectors (UNEP-SBCI, 2009). Reducing energy consumption by implementing energy efficiency and conservation measures is often a key component in a company’s strategy to reduce GHG emissions (Saravanan, 2011). Best available technologies and innovation are key drivers of industrial energy efficiency (UNIDO, 2011). In general, energy conservation protects the environment in the short run by reducing pollution and in the long run by reducing the scope of global climate change (Akinbami andLawal, 2009). The firms’ previous experience with work about the environment, e.g., environmental permits from local authorities and environmental management, is important as an explanatory factor (Christoffersen et al., 2006).

The current environmental regulations and policies in all sectors are minimal. Accordingly, the legislative body has an important role to play in preparing the necessary legal infrastructure to protect the interest of all parties and to prompt a wider adaptation of sustainable construction practices; this can only be achieved if the government takes a leadership role in this regard (Majdalani et al., 2006).In general, governmental regulations intend to drive (GHG) (namely $CO_2$) and energy consumption reduction which considered as one of the main driving factors to implement sustainable practices in construction. WBCSD (2008) described that businesses in the building industry need a supportive policy and regulatory framework to achieve dramatic improvements in energy efficiency. In recent years, like other industries, the construction industry has been under severe pressure in order to adopt environmentally friendly approaches and environmental responsibility is nowadays seen as an important competitive advantage (Saravanan, 2011). Laws can stipulate priorities and provide tax incentives, subsidies and penalties but legislation can have drawbacks (Akinbami and Lawal, 2009; UNIDO, 2011). Kyoto Protocol and the Copenhagen agreements issued an "energy saving" and "low carbon economy" mandatory and moral initiative around the world (Chuanzhong and Yingji, 2011). European Union (EU) and the UK government have recently established numerous measures intended to drive Greenhouse Gas (GHG) (namely $CO_2$) and energy consumption reduction within the UK non-domestic sector. The EU Renewable Energy Directive, the Energy Performance of Buildings Directive (EPBD), the UK Low Carbon Transition Plan (LCTP), the Climate Change Act 2008, and the UK Building Regulations are to name a few (Davies et al., 2013b). On other hand, different studies viewed that, energy management in construction can be achieved by meeting the mandatory regulations or statutory targets (Jiang, 2008; UN Global Compact and Accenture, 2012; AlSanad, 2015).

Palestinian environmental law (No.7/1999) concerning the environment defines the regulatory framework for sustainable resource management and its aims are: (Palestinian National Authority, 2000)

1. Protecting the environment from all forms and various types of pollution;
2. Protecting the public health and social welfare;
3. Institutionalization of environmental protection in the economic and social development plans and encouraging the sustainable use of vital resources;
4. Conserving the biodiversity and the sensitive environmental areas, and improving the environmentally damaged areas;
5. Promotion of information gathering and sharing, as well as increasing of public awareness on environmental issues.

Baloi (2003) investigated the benefits that drive the construction organizations in Mozambique to adopt sustainable construction practices, the compliance with the environmental legislation and regulations (avoid liabilities), contribution to the environmental protection and improvement of staff working conditions were the major drivers. Šaparauskas and Turskis (2006) identified external factors push to look for innovations and new sustainable practices in the construction sector as rising competition, running out resources, tightening of environmental protection standards. In reality, main contractors are responsible of environmental management during the pre-construction and construction stages (Baloi, 2003). Maximizing their awareness, knowledge, understanding and expectations of adopting sustainable practices and regulations can result in more attention to these practices during construction (Rettab and Brik , 2008;AlSanad et al., 2011). One effective way to achieve that by introducing proper energy management guidelines, tools and techniques based on prior research carried out in the industry to make sustainable energy construction (AlSanad et al. 2011).

**II. Economical drivers**

Energy management is one of the most promising profit improvement and cost reduction programs available today. An energy cost savings of 5-15 percent is usually obtained quickly with little to no required capital expenditure when an aggressive energy management program is launched (Capehart et al. 2006). The investigation conducted by Jiang (2008) on energy consumption in 26 developed countries had grown at an average annual rate of 0.62 per cent and in the developing countries at an average rate of 4.36 per cent since 1996. It is also estimated that 10% of the new energy purchasing capacity will be reduced accordingly (Ibrik and Mahmoud, 2005). Consequently, the energy conservation policy will be seriously improved in the forthcoming years. Maintaining higher coordination between increasing rate of energy consumption and economic development will result in the stability of the construction industry and economic development in the country (Xundi et al., 2010). Cagno and Trianni (2013) analyzed the drivers for 71 Italian SMEs to adopt energy efficient technologies and practices. Their research highlighted the importance of allowances and public financing as well as the economic pressures of increases in energy prices and fees on emissions. It also found that companies prefer to adopt energy efficient technologies that may provide long term benefits, and that the presence of highly ambitious or entrepreneurial staff within a company, as well as a management receptive of such issues, constituted additional drivers.

Sorrell et al. (2011) argued that energy efficiency is an important strategy that has been adopted and promoted throughout many countries' economies. It is a tangible resource by itself that competes economically with contemporary energy supply options. The common perception holds that energy efficiency of the industrial sector is too complex to be addressed through public policy and, further, that industrial facilities will achieve energy efficiency through the competitive pressures of the marketplace alone (UNIDO, 2007). Economic competitiveness, utilization of scarce capital for development are the main economic benefits offered by energy conservation. Thollander et al. (2013) concluded that reducing overall project cost will increase the company competitiveness, and hence, it will participate in more projects and selected from different clients\owners. Liu et al. (2012) identified the energy management level of competitors and regular internal training of energy saving as important determinants of companies' energy saving. However, because of their fluctuations in reserves and prices and due to the increased costs of power stations, it is very important to consider new measures for energy conservation in both developed and developing countries (Ibrik and Mahmoud, 2005). High energy prices or constrained energy supply will motivate industrial facilities to try to secure the amount of energy required for operations at the lowest possible price (UNIDO, 2007; Christoffersen et al., 2006).

Cost effectiveness is one of the most important considerations for decisions of implementing any development in construction industry (De Groot et al., 2001; Ochieng et al., 2014). In the same line, the importance of the project cost saving for management justifies the increased planning and adopting of energy efficiency measures (Stefan, 2008). Not only does energy conservation reduce energy bills but also it helps improve contractor economic performances (Yaseen, 2008). Xundi et al. (2010) realized the importance of the energy saving in construction industry to achieve economic development. Chang and Ries (2011) argued that one of the preferences for energy saving in urban residential buildings in China is reducing the energy intensity of the construction sector by lowering energy costs, so that, contractors could realize additional profit.

Availability of loans, guarantees, revolving funds and venture capital funds from financial facilities to support sustainable practices can be considered as main driver for more sustainable practices in construction industry (UNIDO, 2011). Additionally, cost savings from energy management can be redeployed within the company to other core activities. For example it can be used for new equipment procurement or extra staff employment (Sustainability Victoria, 2007). It optimizes use of capital resources by directing lesser amounts of money in conservation investment as against capital-intensive energy supply options (Akinbami and Lawal, 2009). This view strongly supported by the increased contractors focus toward efforts that reducing their energy consumption by changing their management behavior and by encouraging firms' management and workers to follow suit in order to ascertain repeat business (Davies et al., 2013a).

Construction energy saving practices are encouraged and supported by various economic incentives such as preferential fiscal and tax policies (Chang and Ries, 2011). Many governments have used energy and/or carbon taxes to raise the price of energy and increase the value associated with every unit of energy consumed, existence of such taxes will encourage the contractors to adopt energy conservation practices so that to reduced project cost (UNEP-SBCI, 2009). On the other side, different forms of governmental financial support proposed, such as subsidies, grants and loans for the construction. Additionally, Chuanzhong and Yingji (2011) demonstrated that, without governments' support, energy saving technology innovation will be too difficult to be applied. UNIDO (2007) reported that, high energy prices or constrained energy supply will motivate industrial facilities to try to secure the amount of energy required for operations at the lowest possible price. Energy management adoption in construction industry can't promoted from contractor side only as decision-making process to invest in energy efficiency improvement is shaped by the behavior various actors within the industry (Worrell and Price, 2001a). Ofori et.al. (2000) proposed that, to increase the consideration to sustainable construction, the construction stakeholders especially the clients, consultants and contractors must be willing to change their attitudes and culture in exploring new territory and willing to adopt new ideas and practices.

**III. Social drivers**

The acceleration of industrialization and urbanization, coupled by the overdevelopment of energy-intensive industries, has driven energy demand to a new high (Jiang, 2008). Energy conservation could be defined as “an applied technique in energy utilization without affecting the standard of living in the society” (Ibrik and Mahmoud, 2005). Based on this definition, the solution to the energy issue is more than keeping the right balance between supply and demand; it must also address the social concerns incurred thereby (Jiang, 2008). Evidence has shown that good corporate governance of environmental and social issues enhances companies’ shareholders value, or at the very least, protects their highly valuable reputations (SCTG, 2000). Social responsibility by adding value health and contributing to improving the way of living encourages the increased attention to apply energy saving system in construction industry (AlSanad et al. 2011).

Education, training and capacity building are all main pillars of a sustainable improvement of the energy efficiency capacity and the implementation of corporate energy management in industry. One of the most important facts that, educating local contractors employees and professionals on energy management requirements will improve the future compliance to these requirements (Ates and Durakbasa, 2012). Kannan and Boie (2003) noted that, employee education on energy conservation was given high priority before implementing any energy saving measures in industry. Turner and Doty (2009) demonstrated that, raising the energy education level throughout the organization can have big dividends. Consequently, energy management program will be implemented much more effectively if management have understood the complexities of energy, and particularly the potential for economic benefits.

Energy security is the major social responsibility rests on construction contractor related to energy consumption. The major contributor for dealing with it is the energy management (Jarnehammar et al., 2008). Energy management could allow emissions reductions and a better social use of energy resources, by distributing energy towards the poorer segments of the population which reducing fuel poverty and improve health of local communities. Energy conservation could also free resources for investment in new machinery and further improvements in the production process help in boosting competitiveness, growth in productivity, employment, wages and improvements in the standard of living (BEER, 2002; UNIDO , 2011). The firms’ external relations also have an impact on their energy activities. The firm can collect technical information through its external relations. External relations can also influence the firms’ more general attitude (Christoffersen et al., 2006). In addition, Wai et al. (2011) argued that top management attitudes, motivation and commitment towards energy management is a significant influence factor when it comes to implementing energy management at construction project level. Positive attitude and commitment towards energy management meant that the top management have a motivation for addressing energy management issues, other than the fact they are required to do so by legislation.

## 2.5 Barriers to adopt energy management strategies in construction.

Sorrell et al. (2011) defined a barrier to industrial energy-efficiency investment as "a postulated mechanism that inhibits a decision or behavior that appears to be both energy and economically efficient". It may exist at various points in the diffusion process of measures to reduce energy use and/or GHG emissions. It has long been recognized that numerous 'barriers' inhibit the adoption of industrial energy efficiency technologies, such as lack of information, shortage of trained personnel and limited access to capital (Sorrell et al., 2011). In reality, barriers to energy efficiency improvement may take many forms, and are determined by the business environment and include decision making processes, energy prices, lack of information, a lack of confidence in the information, or high transaction costs for obtaining reliable information, as well as limited capital availability (Worrell and Price, 2001b). While barriers exist, it is important to note that sound technologies and practices may also provide a strategic and competitive advantage through the development of new markets or new market opportunities (Worrell and Price, 2001b).

The most critical barrier to sustainable construction is the lack of capacity of the construction sector to actually implement sustainable practices. This lack of capacity is a factor both of the number of human resources and the skills levels of these resources. There simply are not enough professionals, tradesmen and laborers who have been trained to support sustainable construction (Plessis, 2002). Capehart et al. (2006) concluded that, the most important single ingredient for successful implementation and operation of an energy management program is commitment to the program by top management. A survey by Shen, et al. (2010) showed that managerial concern was the most important driver for the adoption of green practices by contractors. According to the above research, the main barriers of green construction were classified into four fundamental aspects, i.e. economics, technology, awareness and management, where 15 potential barriers were identified. Effective energy management however requires the use of tools and methodologies that support the strategic decision making process of selecting energy saving measures, which are viable and environmental friendly (Doukas et al., 2009). Moreover, industrial sector policies and programs are designed to address a number of barriers to investment in energy efficiency and greenhouse gas emissions reduction options including willingness to invest, information and transaction costs, profitability barriers, lack of skilled personnel, and other market barriers (Worrell and Price, 2001a).

While it is true that the change to more sustainable construction will incur some costs, there are also associated savings resulting from efficient resource use, higher productivity and reduced risk (Plessis, 2002). General perception between the construction contractors that sustainable construction practices for energy management would inevitably lead to additional costs, delays and reduce profit very often an excuse not to comply with standards and practices based on principles of sustainability. This perception comes because the measures associated with the reduction of environmental impacts required the allocation of additional material, equipment, training, human and financial resources to accommodate process change and innovation (Plessis, 2002; Baloi, 2003). Estimated savings as a result of potentially efficient energy management are not high enough to overcome resistance to spending money. Lack of information about opportunities for better energy efficiency, together with a lack of knowledge on the part of the main persons involved, are key reasons why potential savings are not exploited. The fear of high costs is understandable, but unfortunate (Stefan, 2008).Contractors believe that these will erode their competitiveness due to loss of immediate economic benefits (Tan et al., 2011).

Limited capital availability makes energy efficiency investments compete with other investment priorities especially, for small and medium sized enterprises (SMEs) capital availability may be a major barrier in investing ill energy efficiency improvement technologies due to limited access to banking and financing mechanisms (Worrell and Price, 2001b). Governmental subsidies that lower energy prices can make energy saving investments less attractive (UNIDO, 2011). Governmental support for energy saving such as taxation and the financial support from the financing markets such as funds for energy saving projects almost will enhance the energy management adoption in construction (Chuanzhong and Yingji, 2011).

Building construction challenge, in recent years include reduction of social, economic and environmental impacts of buildings along with their economical nature and increasing of life quality, and for these aims sustainable construction becomes important as building construction has important role in sustainable development (Zabihi et al., 2012). The survey results conducted by Bond and Perrett (2012) on the factors that prevent the incorporation of sustainable features in developments indicated that, low client demand was ranked as the most significant, followed by high costs versus low perceived benefits. The study results suggested that a lack of government incentives is a significant barrier to green building development, implying that increased government incentives would help to overcome the issue of cost. In fact, an energy management standard requires a facility to develop an energy management plan. In companies without a plan in place, opportunities for improvement may be known but may not be promoted or implemented because of organizational barriers. These barriers may include a lack of communication among plants, a poor understanding of how to create support for an energy efficiency project, limited finances, poor accountability for measures or perceived change from the status quo (UNIDO, 2007). Akinbami and Lawal (2009) summarized the barriers to energy conservation in buildings under four main headings, lack of awareness of potentials and benefits, energy supply constraint/Lack of incentive and motivation, inappropriate energy pricing and lack of legislation.

Energy awareness as a means to reduce production costs is not a high priority in many firms, despite a number of excellent examples in industry worldwide (Worrell and Price, 2001b). Optimizing industrial systems for energy efficiency is not taught to engineers and designers at university which learned through experience (UNIDO, 2007). De Groot et al. (2001) conducted a survey among Dutch firms and found that 30% of the companies interviewed were not, or only to a minor extent, aware of new existing energy efficient technologies or practices. Lack of awareness about low cost energy efficiency measure is a basic barrier to improve energy efficiency that compounded by the perception amongst property developers and contractors that energy efficiency measures add significantly to the overall costs of a building project, in particular through costly technological solutions (UNEP-SBCI, 2009). However, at present within the UK construction industry it seems there is a deficiency of available, robust project data which provides awareness of how energy is consumed within different building types across various project life cycles (Li et al, 2010). In some countries public policies and regulatory frameworks do not encourage the development of the construction sector (Shafii et al., 2006).

The study conducted by Baloi (2003) showed that the most significant challenges associated with environmental management include increase in costs, lack of environmental awareness, lack of environmental education and training (both technical and managerial), need for change management, lower supply of green materials and components, poor environmental legislation knowledge, poor communication, and lack of commitment. A major difficulty developing countries face in adopting industrial energy efficiency technologies is lack of access to international best available technology, because of lack of information or the large scale of the necessary investment (UNIDO, 2011).

A review of research on barriers to energy efficiency reveals that a number of different means of categorizing barriers exists. Sorrell et al. (2000) distinguished three main categories: market failures, organizational failures and nonfailures, while Weber (1997) classified the barriers as institutional, economic, organizational and behavioral barriers. Jarnehammar et al. (2008) in their study conducted through SECURE Project of non-technological barriers, such as legal, financial, social and due to organization of the building sector have been explored in 18 demonstration buildings within the participating cities of Malmö, Dublin, Hilleröd and Tallinn, distributed between residential, public and commercial buildings.

Yaseen (2008) grouped the barriers to energy conservation and efficiency in the Palestinian industrial sector under four categories of; management barriers group, knowledge /information barriers group, financing barriers group and policy barriers group. Djokoto et al. (2014) grouped the barriers toward sustainable construction in Ghanaian construction sector into four primary categories, which were:

1) **Cultural barriers:** Which emerged from the change resistance existed in construction sector especially with respect to construction methods practiced and building materials used.

2) **Financial barriers:** It resulted from the fear of higher investment costs for sustainable construction compared with traditional practices and the risks of unforeseen costs.

3) **Steering barriers:** Include but not limited to the lack of building codes, government policies/support and measurement tools amongst others.

4) **Professional barriers**: Capacity/Professional barriers mainly produced from the lack of capacity of the construction sector to actually implement sustainable practices.

Balasubramanian (2012) classified the critical barriers to the adoption of green supply chain management (GSCM) in the UAE construction sector into the following:

I. **External barriers to the organization:** Including barriers such as lack of skilled sustainability professionals, lack of green suppliers & developers, lack of government support, lack of public awareness and demand and market uncertainty are

II. **Internal barriers to the organization:** Including barriers such as lack of cooperation within the supply chain stakeholders, lack of innovative technology in manufacturing and construction, lack of training in green supply chain management, lack of internal sustainability audits within the organization and lack of sustainability certifications like IS0 14001.

In Gaza Strip, as in other developing countries, there is a considerable lack of environmental public awareness about the interrelated nature of all human activities and their effects on the environment. This is due to lack of education, inaccurate or insufficient information and in some cases disinterest because of severe poverty and inhuman living conditions (Enshassi, 2000). Additionally, energy management and efficiency wasn't a very promising area for research and development in local universities as there are no governmental funds available for research and development purposes in the context of energy management and efficiency.

## 2.6 Best activities for energy saving in construction projects

Numerous studies conducted in the field of industrial energy efficiency shows that there are tremendous saving potential that can be achieved through the effective implementation of energy management in industries. Wyk et al. (2011) stated that, best practices can be defined as the most efficient (least amount of effort) and effective (best results) way of accomplishing a task, based on repeatable procedures that have proven themselves over time for large numbers of people. Gorp (2004) reported that, energy management influences organizational and technical procedures, as well as behavior patterns in order to reduce the total operational energy consumption. Effective energy management however requires the use of tools and methodologies that support the strategic decision making process of selecting energy saving measures, which are viable and environmental friendly (Wyk et al., 2011).

According to Wong (1997), there are two kinds of energy saving - technology fixed and operational changes. Technological fixes is a temporary solution and instrument base such as using motion sensor control lighting and air seal. On the other hand, the operational changes are behavior approach which requires the changes of human behavior by using motivation, creating awareness and skill developing. These two approaches are also known as structural and non-structural energy conservation methods (Yen and Wai, 2010). While majority of the literature on the area of sustainable construction focuses on technological solutions for attaining sustainable construction, it could be argued that this is only one part of the solution in addressing the challenge of sustainable construction. Of equal or may be even more significance are the non-technological institutional processes that are in play in transforming sustainable construction policies into project level practice (van Bueren and Priemus 2002). Wai et al. (2006) argued that the behavioral approach is a more simple way to conserve energy and can be very effective and make a difference. Generally, in behavioral approach, there are tremendous opportunities to save energy by engaging with issues such as attitudes, knowledge, awareness and skills (Vesma, 2002). Yen and Wai (2010) reported that non-structural energy conservation method include the followings:

- ❖ Integrating energy conservation concept in the management and co-curriculum and
- ❖ Improving energy awareness and energy use-behavior among users.

UN Global Compact and Accenture (2012) provided a detail on six priority actions the construction industry can take to become more energy efficient and advance their business opportunities in the sustainable energy market ,which are

1. Reduce consumption of raw materials by sourcing recycled, repurposed and renewable resources.
2. Increase the use of renewable energy and alternative fuels.
3. Increase energy efficiency of processes and facilities.
4. Construct and renovate buildings that are more energy efficient over their lifetimes.
5. Facilitate product recycling and identify opportunities to beneficially reuse waste.
6. Promote energy-efficient building codes and regulatory incentives for more energy-efficient building projects.

Shafii et al. (2006) introduced the following strategies and recommendations for the construction industry to move towards sustainability:

- ➢ Education and training should incorporate sustainable development concepts and made it well known and accepted by all people. This will increase the level of awareness both among the actors in the entire construction process, as well as the general public;
- ➢ Initiatives involving planning and construction should be through adapted regulations, standards or fiscal measures and incentives;
- ➢ Building owners and clients should play important roles in disseminating sustainable construction;
- ➢ Understanding sustainable construction through common definitions and language to address the issues;
- ➢ Designers adopting an integrated approach to design (integrated design approach);
- ➢ Improvement of the building construction process as opposed to the traditional methods;
- ➢ Building users should consider the environmental issues as one aspect of productivity;
- ➢ Manufacturers of building materials/ products taking life cycle considerations as the basis of product development;
- ➢ Building maintenance organizations should consider environmental consciousness as a factor of competitiveness;
- ➢ The development of tools to help in decision making.

Some activities and practices that may affect the company behavior or the management and staff behavior to attain more energy saving in construction projects will be discussed here. These activities may involve institutional, governmental or organizational aspects. Technical activities which based on using specific instruments to save energy are not discussed.

- **Strategies, policies and programs of energy management**

Price and Worrell (2000) argued that, the most effective way to improve industrial energy efficiency is through an integrated approach, where a number of policies and programs are combined to create a strong overall industrial energy efficiency policy that addresses a variety of needs in many industrial sectors. Sustainability policy is a statement of commitment from top management about the goals to be achieved. It is a commitment for protecting the environment and enhancing social responsibility (Tan et al., 2011). With focus on energy issue only, Carbon Trust (2011) stated that an energy policy is "a written statement of a commitment to managing energy and carbon emissions". Abdelaziz et al. (2011) demonstrated energy policy as the manner by which a given entity has decided to address issues of energy development including energy production, distribution and consumption. It sets out energy related guidelines, operating principles and long term overall objectives for the company. It is used, over time, as a measurement for the effectiveness of energy management (Kahlenborn et al., 2010).

Sustainability Victoria (2007) pointed out that, resource management policy is not necessarily the invention of a new policy document, but rather the integration and/or review of existing policy statements to include resource management. This is then supported by new strategies for resource management, decision making and improvement planning. An operational energy policy task should define energy-related goals and principles and communicate them to the employees and other stakeholders in the company (Sorrell et al., 2011). A formal written energy policy acts as a guidance of both management and the operating divisions of the industry. It acts also as a public expression of the industry's commitment to energy consumption and the environment protection (Ndayiragije, 2006). A well written energy policy that has been authorized by management is as good as the proverbial license to steal. It provides the energy manager with the authority to be involved in business planning, new facility location and planning, the selection of production equipment, purchase of measuring equipment, energy reporting, and training—things that are sometimes difficult to do (Turner and Doty, 2009). To be most effective, energy efficiency policies should be shaped according to the factors, e.g. characteristics of the enterprises, and the context in which they operate, that influence the barriers to the adoption of energy-efficient technologies and practices (Trianni et al., 2013). Company energy policy should also be regularly assessed and, if required, adapted to changing circumstances (Kahlenborn et al., 2010). There are many types of strategies, policies and programs that have been used in several countries worldwide to improve energy efficiency in the industrial sector. Price and Worrell (2000) classified these policies and programs as follows**:**

- Audits/assessments
- Agreements/targets

- ❖ Reporting/benchmarking
- ❖ Regulations/standards
- ❖ Fiscal policies
- ❖ Information dissemination and demonstration
- ❖ Research and development.

ISO (2008) required top management in industrial organizations to define and document its policy for managing energy and it should include the followings:

1. Address all significant energy uses,
2. Be appropriate to the defined scope and boundaries of the energy management system,
3. Be relevant to the nature and scale of energy use, and
4. Be consistent with the policies of other management systems.
5. In defining the energy policy, top management shall state its commitment to meeting the requirements of this standard, legal, and other requirements to which the organization subscribes and continual improvement in energy performance.

Tanaka, (2011) described two general policy approaches and various streams used by governments to encourage industry to improve its energy efficiency Figure (2.5). The general approaches are:

**I. Company or sector specific measures;**
**II. Industry or economy wide measures.**

The measures illustrated in Figure (2.5) can be described as follows:

- The measures (1): include regulations, directed financial instruments and agreements;
- The measures (2): include energy taxes, carbon taxes and emission trading.
- The measures (3): include other policies which create an environment for the industry to enhance energy conservation, for example, education and training.
- The measures (4): Industrial associations or federations, acting as intermediaries between government and individual industrial companies, can help in assessing circumstances by collecting, compiling, aggregating and communicating data which can be used for policy development and policy positions of the industry. (Tanaka, 2011).

An energy strategy is " a document setting out an action plan of how energy will be managed in the organization to meet the policy objectives" (Carbon Trust, 2011). Ates and Durakbasa (2012) defined it as “ is a method of establishing an authority mechanism requiring others within the organization to comply with the reporting requirements necessary to properly manage energy”. Furthermore, the energy strategy is considered an important instrument which provides clarification on energy-related plans and priorities (Ates and Durakbasa, 2012).

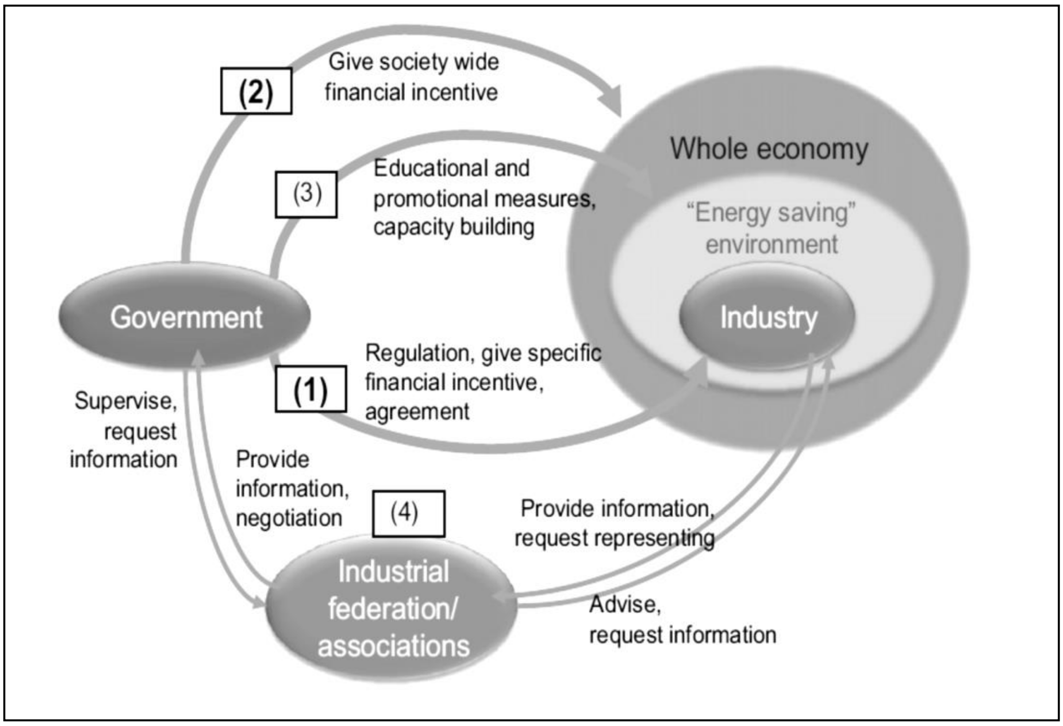


Figure (2.5): Incentive and information ''streams'' between government and industry. (Source: Tanaka, 2011)

Based on numerous energy management strategies developed for industrial sector, United Nations Centre for Human Settlements (UNCHS, 1991) suggested the basic strategies for improving energy efficiency in construction sites including:

- ✓ Conducting energy audits on typical construction sites to identify energy use and energy saving opportunities; making site staff aware of the energy implications of all site activities, and introducing incentives for energy saving (Carbon Trust, 2011);
- ✓ Examining the energy efficiency of all mechanical plant used; replacing inefficient plant with more efficient plant; reducing the unnecessary use of plant; ensuring that all plant is properly serviced and maintained (poor maintenance can increase energy use by 15−20 per cent); considering the selective replacement of mechanical plant with the use of manual labor;
- ✓ Examining energy efficiency of all buildings used in the construction process, and where appropriate, upgrading them;
- ✓ Examining the extent of use of transport of materials etc. to and within the site, with a view to reducing journeys and utilizing the most energy efficient means of transport available; selecting where possible only local sources of materials supply;
- ✓ Examining the embodied energy in temporary works, and replacing high energy materials with lower energy materials in temporary works where possible,
- ✓ Looking for opportunities to save wastage of materials, such as excessive concrete in foundations, excessive cement in concrete mixes; looking for ways to reduce materials use by the use of closer supervision and quality control;
- ✓ Separating all waste materials generated to facilitate their recycling.

❖ **Energy audit**

A successful program in energy management begins with a strong commitment to continuous improvement of energy efficiency. A first step once the organizational structure (energy coordinator, management team) has been established is to conduct an assessment of the major energy uses in the facility to develop a baseline of energy use and set goals for improvement (Worrell et al., 2004;Vesma, 2012). Akinbami and Lawal (2009) argued that development of adequate database is one of the main strategies to promote energy conservation in the building sector. This requires the identification and elimination of points of inefficiencies by collecting and proper analysis of relevant data, which can help to indicate whether or not there is need for improvement in energy use. A systematic review and analysis of energy consumption forms the basis for an increase in energy efficiency. The higher the consumption the more detailed measurement should be and, consequently, the easier it is to ascertain the savings potential (Kahlenborn et al., 2010). Saidur (2010) stated that energy audit is "a systematic approach, to monitor industrial energy consumption and to pinpoint sources of wastage". APO (2008) provided another description for industrial energy audit which is "an effective tool in defining and pursuing a comprehensive energy management program within a business". Energy audit is the key for decision-making in the area of energy management; it is defined as "an inspection, survey and analysis of energy flows for energy conservation to reduce the amount of energy input into the system without negatively affecting the output" (Abdelaziz et al., 2011).

The primary objective of the energy audit is to determine ways to reduce energy consumption per unit of product output or to lower operating costs (APO, 2008). Energy Audit provides information regarding current energy use patterns, establishing a benchmark (Reference point) for managing energy in the organization and also provides the basis for planning a more effective use of energy throughout the organization (Price and Worrell, 2000; Bureau of Energy Efficiency, 2010). A well done energy audit will always help managers to identify areas where waste can occur and where scope for improvement exists (APO, 2008). Saidur (2010) pinpointed the following benefits that can be achieved through energy audit:

- ✓ Identifies energy losses for corrective action;
- ✓ Impact of operational improvements can be monitored;
- ✓ Reduces the specific energy consumption and operating costs (approximately 20–30%) by systematic analysis;
- ✓ In addition to the potential dollar savings from an energy audit, the results may lead to environmental benefits such as greenhouse gas reductions, environmental credits as greenhouse gas reductions;
- ✓ Improves the overall performance of the total system and the profitability and productivity.
- ✓ Averts equipment failure;
- ✓ Estimates the financial impact of the energy conservation projects;
- ✓ Serves as a very good self-auditing and correction system for performance improvement.

The traditional energy audit involve collecting data on all of the major energy consuming processes and equipment in a plant as well as documenting specific technologies used in the production process and identifying opportunities for energy efficiency improvement throughout the plant (Goldberg et al., 2011). The individual enterprise audits were done by the company itself and/or by independent consultants. Sound industrial energy auditing program provides regulations, standards, and guidelines for conducting standardized energy audits, collecting energy auditing results, analyzing and evaluating energy audits, as well as incentives and supporting measures for participation parties. An industrial energy auditing program should also provide training and certification of energy auditors, who have a significant impact on the quality and output of energy audits (Price and Lu, 2011). In general, energy audit requires a systematic approach from the formation of a suitable team, to achieving and maintaining energy savings (Saidur, 2010). Bureau of Energy Efficiency (2010) stated that the type of energy audit to be performed depends on function and type of industry; depth to which final audit is needed and potential and magnitude of cost reduction desired. Preliminary audit and detailed audit are the major types Energy audits conducted in energy management program (APO, 2008; Saidur, 2010; Abdelaziz et al., 2011).

**A. Preliminary energy audit:**

The preliminary energy audit uses existing or easily obtained data. It is the simplest and quickest type of audit and conducted in a limited span of time. It involves minimal interviews with site-operating personnel, a brief review of facility utility bills and other operating data. It focuses on major energy supplies and demands of the industry (Price and Lu, 2011; Abdelaziz et al., 2011). Preliminary energy audit is a relatively quick exercise and conducted to: (APO, 2008; Bureau of Energy Efficiency, 2010)

a. Determine energy consumption in the organization;
b. Estimate the scope for saving;
c. Identify the most likely (and easiest areas) for attention;
d. Identify immediate (especially no-cost/low-cost) improvements/savings;
e. Set a reference point;
f. Identify areas for more detailed study/measurement.

**B. Detailed energy audit**

Detailed energy audit provides a comprehensive energy project implementation plan for a facility since it evaluates all major energy-using systems (APO, 2008). The detailed audit providing a dynamic model of energy-use characteristics of both the existing facility and all energy conservation measures identified (Saidur, 2010). Collecting more detailed information about facility operation and performing a more detailed evaluation of energy conservation measures identified (Abdelaziz et al., 2011). Detailed, or comprehensive, energy audits can be targeted at specific systems or can cover most processes, equipment or facilities, in order to identify more wide ranging energy efficiency measures, on the other hand, it is enabled to provide detailed cost effective analysis of all identified measures and technologies, based on plant's specific operating conditions (Price and Lu, 2011). Bureau of Energy Efficiency (2010) marked ten steps of detailed energy auditing grouped into three phases: Phase I – pre-audit phase, Phase II – audit phase, and Phase III – post-audit phase. The proposed steps and phases described in Table (2.1) below.

Usual output is formal audit report recommending a package of improvements, with costs and paybacks assigned to each recommended measure (UNIDO, 2007; Goldberg et al., 2011; Vesma, 2012). An energy audit report is often a key component of industrial energy efficiency programs and strategies which has also been considered as a supporting policy tool for energy savings policies and plans such as voluntary agreements (UNIDO, 2007; Price and Lu, 2011). Top management of the organization also can use the documented energy audit results to set strategic energy management measures (Kahlenborn et al., 2010). An evaluation of programs in 11 different countries found that on average 56% of the recommended measures were implemented by audit recipients (Nadel et al., 1991).

Table (2.1): Ten steps methodology for detailed energy audit.
(Source: Bureau of Energy Efficiency, 2010)

| Step no. | Plan of action |
|---|---|
| **Phase I Pre-audit phase** | |
| Step 1 | Plan and organize Walk-through audit Informal interview with energy manager. |
| Step 2 | Conduct of brief meeting/awareness program with all divisional heads. |
| **Phase II Audit phase** | |
| Step 3 | Primary data gathering, process flow diagram and energy utility diagram. |
| Step 4 | Conduct survey and monitoring. |
| Step 5 | Conduct of detailed trials/experiment for the highest energy consumption equipment. |
| Step 6 | Analysis of energy use |
| Step 7 | Identification and development of energy conservation (ENCON) opportunities |
| Step 8 | Cost benefits analysis |
| Step 9 | Reporting and presentation to the top management |
| **Phase III Post-audit phase** | |
| Step 10 | Implementation and follow up. |

### ❖ Energy plan

Nowadays, the role of energy management has greatly expanded in industries. Planning is one of the most important elements of the energy management program as it enables organizations to give constant attention to energy management program through the planning of events throughout the year. Furthermore, planning of energy management requires the organizations to set objectives and targets which provide the means to transform policy into action. Setting a saving target holds them to determining criteria of success so that progress can be made toward an improved energy management system and energy savings (Ates and Durakbasa, 2012). Top management of the company participates in planning of various energy management projects on a regular basis. Annual reports of many companies should mention the details of energy conservation activities and various achievements by the company regarding energy conservation projects (Abdelaziz et al., 2011). An energy action plan outlines a company's plan for improving energy efficiency during the period covered by energy efficiency targets. Energy action plan is primarily the guidance for the internal implementation of the activities that will be undertaken to reach the energy saving target. It also serves as a reference to evaluate progress on an annual basis (UNIDO, 2007).

Energy action plan should include a description of the facility with respect to energy, a description of the energy efficiency measures considered, a description of the planned energy efficiency measures, a timeframe for implementation of the energy efficiency measures, and expected results in terms of energy efficiency. Once the energy action plan is drafted, it is typical for an independent third party to review the plan and make suggestions for adjustments, if needed. If conditions change at the facility or if planned energy efficiency projects change, the energy action plan should be revised and submitted to the independent third party for additional review (UNIDO, 2007; Kahlenborn et al., 2010). Action plan needs to be manageable in size and clearly structured so that it provides clear information, and can be easily used as a key document in the development of the resource management program. Sustainability Victoria (2007) described the general areas that may be included in an action plan:

- Summary of the background data (e.g. using an initial resource review of the whole facility which can be used to establish the baseline for the development of the resource management program).
- The purpose and scope of the plan.
- Priorities for action (e.g. issues requiring urgent action; issues where no immediate action is required, but there is a need for longer term improvement; and strategically important areas for future development).
- The process or means of achieving the objectives and targets(s).
- The timeframe and resources required.
- Allocation of responsibilities.
- Evaluation processes to assess the effectiveness of the program. An executive summary outlining the key information on projects (e.g. potential resource

- savings and paybacks, greenhouse gas emissions, quality improvements, monitoring of process, savings in maintenance)

- **Compliance with regulations/standards:**

Mandatory requirements are regulations or legal mandates established by national governments, which often require facilities to conduct energy audits, or meet energy efficiency improving targets ,or establish a certified energy/environmental management system (Price and Lu, 2011). According to Ang and Wilkinson (2008), regulation is the tool government uses to drive the market toward more energy-efficient buildings. Regulations can require that industrial facilities conduct energy audits, employ an energy manager, or adopt an energy management system (Abdelaziz et al., 2011). Mandatory energy consumption reporting, mandatory energy saving plans and mandatory maintenance are some of the mandatory regulations used in industry (WEC, 2004).

Energy regulations are essential for any successful energy policy. Energy management includes a number of regulations for energy consumption and direct/ indirect electrical loads (Ibrik and Mahmoud, 2005). Measures to promote energy conservation in the country need an adequate legislative backing. This will involve the institutionalization of standards and codes, as well as incentives/motivation that will enhance national promotion of energy conservation (Akinbami and Lawal, 2009). Different policies and regulations were developed to promote green technologies in construction worldwide that required the construction contractors to comply with it to achieve progress in their business (Berardi, 2013). Most countries have introduced policies to reduce greenhouse gas emissions from buildings through measures to improve energy consumption and greenhouse gas emissions (UNEP-SBCI, 2009; Davies et al. 2013). Regulations and agreements can target many aspects of industrial energy use, such as: (Tanaka, 2011)

- Equipment efficiency levels;
- Plant or process efficiency levels or configurations;
- Energy management activities.

- **Fiscal policies**

Direct subsidies and tax credits or other favorable tax treatments have been a traditional approach for promoting activities that are socially desirable. An example of a financial incentive program that has had a large impact on energy efficiency is the energy conservation loan program that China instituted in 1980 (Worrell and Price, 2001b). Fiscal policies include imposition of taxes, tax rebates, investment tax credits, and establishing investment bank lending criteria for promotion of energy efficiency. Taxation policies are a mandatory means for influencing the introduction of energy efficiency. Taxation policies can also influence energy efficiency through the use of tax rebates or investment tax credits. Investment bank lending criteria can be established to give higher priority for funding projects that improve energy efficiency (Price and Worrell, 2000; Abdelaziz et al., 2011).

Governments impose taxes on energy, and in a few cases $CO_2$ emissions, to raise revenues and encourage energy efficiency and fuel switching also it give industry nontax financial incentives, such as subsidies, preferential loans and R&D funds, for energy efficiency investment (Tanaka, 2011). To regulate the behaviors of wasting resources, Governments have therefore used energy and/or carbon taxes to raise the price of energy and increase the value associated with every unit of energy consumed (Chuanzhong and Yingji, 2011; UNEP-SBCI, 2009). Developed countries governments promote perfect incentive mechanisms for energy saving including taxation relief, duty privilege, financial subsidies and other appropriate policies to these enterprises with good effect of energy saving (Chuanzhong and Yingji, 2011).

- **Agreements/Targets**

Since the early 1990s there has been a significant increase in the use of voluntary approaches to deal with various environmental problems, including GHG emissions (Saidur, 2010). Standards for energy management systems have shown to be central in energy savings agreements between the government and enterprises and have usefully contributed to effective energy savings performance. Companies that have obtained certification have often achieved energy savings beyond the expectation of the agreement, typically making savings of 10-20% within the first five years (Goldberg et al., 2011). These agreements between government and industry aim to facilitate voluntary actions with desirable social outcomes, which are encouraged by the government, to be undertaken by the participants, based on the participants' self interest (Price and Worrell, 2000). An agreement can be formulated in various ways: two common methods are those based on specified energy efficiency improvement targets and those based on specific energy use or carbon emissions reduction commitments (Abdelaziz et al., 2011).

Worrell and Price (2001a) defined the voluntary industrial sector agreements as "a commitment for an industrial partner or association to achieve a specified energy efficiency improvement potential over a defined period". A voluntary agreement generally is a contract between the government (or another regulating agency) and a private company, association of companies or other institution. Voluntary agreements can have some apparent advantages above regulation, in that they may be easier and faster to implement and may lead to more cost effective solutions (Worrell and Price, 2001b; WEC, 2004).

Organization shall establish, implement and maintain documented energy objectives and targets, at the relevant functions and levels within the organization (ISO, 2008).Target setting agreements, also known as voluntary agreements, have been used by a number of governments as a mechanism for promoting energy efficiency within the industrial sector. Three examples of model target setting agreement programs are the UK's Climate Change Agreements, Denmark's Energy Efficiency Agreements, and The Netherlands' Long-Term Agreements (UNIDO, 2007). Targets must allow for inclusion of a wide range of energy saving activities. This provides flexibility for the industrial partners to achieve the targets in a manner that is cost effective and efficient (Worrell and Price, 2001b). The key elements of a target setting program are the: (UNIDO, 2007)

- Target setting process;
- Identifying energy saving technologies and measures, using energy efficiency tools, guidebooks;
- Benchmarking current energy efficiency practices,
- Establishing an energy management plan ;
- Conducting energy efficiency audits;
- Developing an energy savings action plan;
- Developing incentives and supporting policies;
- Measuring and monitoring progress toward targets, and
- Program evaluation.

Effective target setting agreement programs are based on signed, legally binding agreements with realistic long term (typically 5-10 year) targets, require company level implementation plans for reaching the targets, require annual monitoring and reporting of progress toward the targets, include a real threat of increased government regulation or energy/GHG taxes if targets are not achieved, and provides effective supporting programs to assist industry in reaching the goals outlined in the agreements (WEC, 2004). The effectiveness of voluntary agreements is still difficult to assess, due to the wide variety and as many are still underway (Worrell and Price, 2001b).

- **Reporting/Benchmarking**

Programs or policies that promote or require reporting and benchmarking energy consumption have been implemented in some countries (Worrell and Price, 2001b). Benchmarking of energy consumption internally (historical / trend analysis) and externally (across similar industries) are two powerful tools for performance assessment and logical evolution of avenues for improvement (APO, 2008). Reporting facility energy use has been shown as an effective means of raising management awareness of internal energy consumption trends while benchmarking energy use provides a means to compare the energy use of one company or plant to that of others producing the same products (Price and Worrell, 2000; Worrell and Price, 2001b; UNIDO, 2007). Benchmarking energy performance permits: (APO, 2008)

- Quantification of fixed and variable energy consumption trends against production levels;
- Comparison of industry energy performance with respect to various production levels (capacity utilization);
- Identification of best practices (based on external benchmarking data);
- Scope and margin available for energy consumption and cost reduction ;
- Basis for monitoring and target-setting exercises

- **Information dissemination and demonstration**

Information dissemination and demonstration programs provide industries with information on energy efficiency technologies and practices that may be difficult, costly, or time consuming for individual enterprises to gather (Price and Worrell, 2000). Improvements in energy efficiency will not happen spontaneously. Energy management influences organizational and technical procedures, as well as behavior patterns, in order to reduce the total operational energy consumption (Kahlenborn et al., 2010). People need help and guidance, the people levels of energy awareness, their attitudes, what motivates them and what knowledge (or even practical skills) they might need are the major characteristics related to energy management should be investigated and developed (Vesma, 2012).

Yaseen (2008) indicated that applicable energy saving techniques have three critical elements, they are the awareness of the need, access to solutions and visibility of economic benefits. The lack of or limited awareness of the potentials of energy efficiency is about the most important obstacle to wide scale adoption of energy efficiency measures and technologies in the country generally and particularly in the construction sector (Akinbami andLawal, 2009). There is therefore a need for awareness raising activities across the spectrum of stakeholders about low cost energy efficiency measures that have been proven to be equally, if not more, effective than the application of high cost technologies (UNEP-SBCI, 2009). Just bear in mind that there are at least two categories of awareness that you will want to test. One is awareness of how and where the organization uses energy; the other is awareness of what individuals can and should be doing to minimize consumption (Vesma, 2012). In the UAE only 38% of companies recognize the importance of environmental issues in their supply chain strategy and 60% of the construction companies do not take into consideration green supply chain concerns while making strategic decisions (Rettab and Brik , 2008). At present, within the UK construction industry it seems there is a deficiency of available, robust project data which provides awareness of how energy is consumed within different building types across various project life cycles (Dixit et al., 2012).

Awareness of energy efficiency and conservation by top management of companies is an important incentive to adopt energy efficient techniques (Yaseen, 2008). Public awareness could implement policies and programs on creating mass awareness and extending simplified information and knowledge about energy conservation topics. In order to achieve this purpose, it is possible to use available methods and techniques, like video films, radio and TV, local press, posters, communication and networking. Energy education is another way to establish a proper energy education scheme in the field of energy conservation by means of introducing new courses for both conventional and renewable energy sources. Such education schemes may include energy basic principles, consumption loads and the relevant environmental effects (Ibrik and Mahmoud, 2005). Energy conservation training courses, in general, focus on legal, technological, environmental, social and economic dimensions of energy efficiency as shown in Figure (2.6) (Abdelaziz et al., 2011).

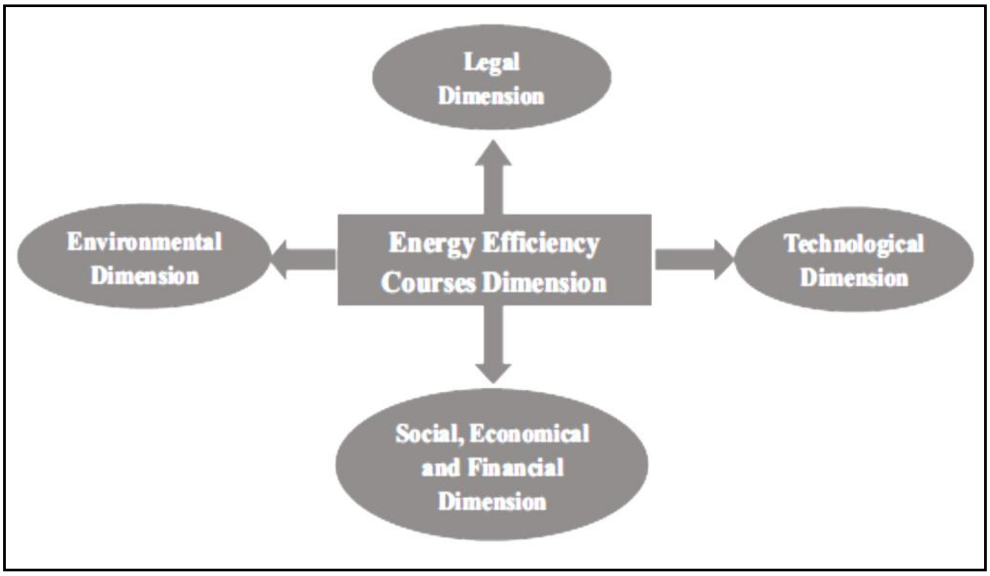


Figure (2.6): Energy efficiency courses and its dimensions.
(Source: Abdelaziz et al., 2011)

AlSanad et al. (2011) asserted that the rate of progress towards sustainability in construction depends mainly on improving awareness, knowledge and understanding of the impacts of people actions. The knowledge of the construction stakeholder in sustainability concept can be achieved by attending training courses, workshops, conferences, and study tours for similar projects worldwide. Dixit et al.(2010) studied the importance of the available local supporting tools for energy conservation, such as energy and public awareness, energy regulations, energy information and programming. Information programs are designed to assist energy consumers in understanding and employing technologies and practices to use energy more efficiently (Worrell and Price, 2001b).

An important aspect for ensuring the successes of the action plan is involving personnel throughout the organization. Personnel at all levels should be aware of energy use and goals for efficiency. Staff needs to be trained in both skills and general approaches to energy efficiency in day to day practices. In addition, performance results should be regularly evaluated and communicated to all personnel, recognizing high achievement (Worrell et al., 2004; UNIDO, 2007). It is important to note that an increase in efficiency and dissemination the awareness toward energy conservation through workshops and capacity building for the involved staff must be a priority for the Palestinian territories in view of the fact that energy resources are so scarce (Yaseen, 2008). Muhaisen and Ahlbäck (2012) described the necessity of conducting informed social dialogue and awareness raising related to sustainable construction and green jobs in Gaza strip. The conducted dialogue and increased awareness can help in introducing new methods, technologies and solutions for sustainable practices in Gaza construction industry.

With sustainability awareness, sustainability policy within contractor organizations is a must. Measures to increase energy efficiency can only be taken and implemented sustainably if management recognizes and supports energy management. If directors have little or no interest in the subject, the result is a disincentive for such projects, because sometimes measures need to be enforced despite the doubts of employees and persons in managerial positions (Stefan, 2008).

- **Research and development (R&D)**

Research and development of technologies is defined as creative work undertaken on a systematic basis to increase the stock of knowledge, including knowledge of people, culture and society, and the use of this knowledge to devise new applications. Different stages of R&D can be distinguished, including basic research, applied research, experimental work and demonstration. R&D can have various goals, depending on the barriers to be tackled to implement a technology (Price and Worrell, 2000). There is a great need for funding of research for appropriate research institutes into the various building designs that allow for a longer period of use of passive energy than obtain presently (Akinbami and Lawal, 2009).

- **Technical changes**

Developing countries need to address the behavior and choices of people as the main enablers for sustainable construction as they come from a people-centered view of development. This means that a change in attitudes of people towards production is urgent (Baloi,2003). Buildings, infrastructure and the environment are part of our living environment thus affecting our living conditions, social wellbeing and health. Hence, it is important to explore environmentally and economically sound design and development techniques for buildings and infrastructure for them to be sustainable, healthy and affordable, and also which encourage innovation in construction (Shafii et al., 2006). There is considerable technical potential for improving industrial energy efficiency, such improvements frequently involve the adoption of established technologies whose performance is well proven and which involve relatively little technical risk (Sorrell et al., 2011). Procedures manual for energy management may refer to detailed work instructions that explain exactly how the work should be performed. The company must document those procedures and inform all employees about its contents. Each procedure manual should :(UNIDO, 2007)

- Specify procedure purpose and intended scope;
- Describe how an activity is to be performed;
- Describe who is responsible for carrying out the activity;
- Explain why the activity is important to the efficient operation of the system;
- Identify a timetable for the activity;
- Explain what equipment is required to complete the activity;
- Detail the documents and records that need to be kept.

Construction sector energy efficiency improvement measures can be particularly in project implementation phase. Construction contractors are knowledgeable of construction process and characteristics of various building materials and plants, their roles in contributing to better project sustainability are significant. They can provide information and suggestions about the environmental effects of construction activities and various materials and plant, such as waste generation, air, noise, pollution, safe uncertainties, energy consumption and water pollution (Shen et al., 2010). Compared with the widely accepted building technologies, GHG emission reduction strategies in construction are in general: (Saravanan, 2011)

- Minimization of the energy demand for the production, transport, reuse or recycling of building materials;
- Utilization of renewable energies for production, transport and performance;
- Fabrication of products with an extended lifetime;
- Utilization of building products and materials, which can be reused or recycled;
- Utilization of nature, space and material saving construction methods;
- Design of multifunctional buildings with an extended lifetime;
- Design of climate responsive buildings with a minimal consumption of energy.

BEER (2002) suggested different strategies to reduce embodied energy in construction, without compromising longevity or efficiency, these are:

- Reuse existing buildings and structures wherever possible (provided their energy costs in use can be reduced to an acceptable level).
- Design buildings for long life, with ease of maintenance and adaptability to changing needs
- Construct buildings and infrastructure out of local and low-energy materials where possible
- Reduce the proportion of high rise, detached or single-storey developments
- Design layouts which minimize the extent to roadway and utility pipe work per dwelling create a strategy.

Technological changes aimed to increase output using the same amount of energy or that deliver the same output using less energy. These changes include replacing old technologies, adopting energy saving technologies, improving processes and optimizing systems, and employing energy management practices. They also include using more high quality energy, such as gas and electricity; innovating product designs; and changing the output mix (UNIDO, 2011). Cost effective and alternate construction technologies, apart from reducing cost of construction by reduction in quantity of building materials through improved and innovative techniques or use of alternate low-energy consuming materials, can play a great role in reduction of CO2 emission and thus help in cost effectiveness (Sengupta Nilanjan, 2008).

Plessis (2002) explained many techniques to reduce resources usage in construction and to improve energy efficiency in buildings such as reducing building material wastage, increasing the use of recycled waste as building materials, construction stockholders education, the development of an energy code, improvement of systems (air-conditioning, heating, water heating), improvement of insulation, use of alternative energy sources and passive solar design improvements. Morel et al. (2001) have used indicators such as energy consumption and amount of building materials to be transported for expressing environmental impacts of construction. The researchers revealed that by adopting local materials the amount of energy used in building decreased by up to 215% and the impact of transportation by 453%. The study conducted by Xundi et al. (2010) resulted in some important measures to be taken to achieve faster economic development with less energy consumption in construction industry which including using new technology, new method and economic policy to close the gap between the increasing rate in energy consumption and economic development and more attention from all the stakeholders being paid to saving energy than before will be good option.

Industries must try to improve the existing systems with their equipment and units and increase efficiency which can be done through energy audits (Ibrik and Mahmoud, 2005). Hence, it is still helpful to know what activities and equipment are likely to consume the most energy. In terms of priority of action for an energy management program, the largest areas of energy consumption should be examined first. Energy accounting is a system used to keep track of energy consumption and costs. A basic energy accounting system has three parts: energy use monitoring, an energy use record, and a performance measure. Energy accounting is the art and science of tracing energy dollar flow through an organization (Capehart et al. 2006).

Palestinian energy efficient building code and guide on the design of energy conservation buildings have been developed in occupied Palestinian territory. Furthermore, developing engineering skills and training construction sector stakeholders on green building is taking part of some projects. The integration of the concept of sustainable buildings into vocational training programs is being assessed. In addition to the above, several new projects cover the piloting of green schools and clinics as well as energy conservation, geothermal and solar energy harvesting, natural ventilation, and rain water harvesting activities (MoPAD, 2012). Construction industry should learn the experience of the advanced technology of energy conservation and new energy development and utilization from developed countries, especially from the United States and Japan (Chuanzhong and Yingji, 2011).

Chapter 3

# Research methodology

The previous chapters have provided several information about local construction industry, energy situation, sustainability and energy saving and management situation in industrial sector focusing on construction industry. The literature review presented in depth information about energy saving and management, its importance, principles, drivers and major barriers to adopt it in the construction sector. It also explored various activities to save energy in construction and their various impacts.

This chapter describes the methodology of this research. It emphasizes on the research approach, strategy and data collection and analysis methods adopted to achieve this research objectives. Primarily, this chapter explains the processes used to accomplish the research objectives.

## 3.1 Introduction

Remenyi et al. (2003) defined research methodology as " the overall approach to a problem which could be put into practice in a research process, from the theoretical underpinning to the collection and analysis of data ". Research methodology lies at the heart of the research to indicate the principles and procedures of logical thought processes which are implemented by a scientific investigation (Fellows and Liu, 2008). Kothari (2004) reported that it is a way to systematically solve the research problems. As per the previous declaration, it is clear that research methodology focuses on the problems to be investigated in a research study and hence is varied according to these problems to be investigated. Thus, identifying the research methodology that best suits a research in hand is important, not only as it will benefit achieving the research objectives, but also as it will serve establishing the credibility of the work.

This study is a descriptive research as it tries to describe the current status of energy management practice in construction contracting firms working in Gaza Strip. Accordingly, it was mainly focused on energy management development and practice during the construction process in the contracting companies working in Gaza Strip. This chapter discusses the choice of the method used for this particular research. This discussion encompasses three principal aspects, as follows:

- ✓ **First part: Research methodology and approach.**

Why quantitative approach in this particular case was used as principal methodology. Discussion under this section principally focuses on benefits of using this approach in construction research.

- ✓ **Second part: Data collection and sampling.**

How data was collected. This part of discussion focuses on the data collection approach, the instrument for data collection, target population, sampling method, sample size, and other related issues.

- ✓ **Third part: Data analysis and interpretation.**

Is devoted to discuss how data was analyzed and validated using computer programs. In this part of the chapter, discussion is made on data analysis approach, use of computer software, and related issues pertaining to data analysis.

In addition to addressing above three main points, this chapter also highlights several issues during the research design including experts reviews and questionnaire pretesting.

In general, the aim of this study is to investigate and to create an understanding of how energy issues are managed during the construction process in construction contracting firms working in Gaza Strip. To achieve this aim, five different objectives have been proposed, which are:

1- To assess the local contractors level of awareness about energy issues and energy management in construction industry.

2- To identify the degree of practice of energy saving and management during construction process in local contracting firms.

3- To explore the major drivers enhancing the local contractors to adopt energy management during project construction.

4- To identify the key barriers to the implementation of energy management in local contracting companies during the project construction.

5- To pinpoint the contractor best activities to reduce energy consumption during the project construction .

## 3.2 Research approach

Selecting an appropriate research approach is a critical important decision to satisfy the objectives of the study and to fit with the available and needed information. The quantitative approach and the qualitative approach are the basic two approaches to scientific researches. The difference between these two approaches lies in the nature of collected data and the way in which this data is analyzed (Kothari, 2004; Naoum, 2007).

The quantitative research is objective and scientific in nature which involves the generation of data in quantitative form that can be subjected to rigorous quantitative analysis using standard statistical techniques in a formal and rigid fashion (Naoum, 2007). In other words, in quantitative studies, researchers should know exactly what they are looking for before they commence their study (Neill, 2007). Naoum (2007) opposed that quantitative approach can be best suited when to collect factual evidence or to study the relationship between concept, question or an attribute to test a particular theory or hypothesis.

Qualitative approach to research is concerned with subjective assessment of attitudes, opinions and behaviors. Research in such a situation is a function of researcher's insights and impressions. It bases its conclusions on discussions, thinking and knowledge in order to help to improve the understanding of an area of research (Kothari, 2004; Tayie, 2005). This approach to research generates results either in non-quantitative form or in the forms which are not subjected to rigorous quantitative analysis (Kothari, 2004; Naoum, 2007). Qualitative approach helps to find out what is happening in a particular area of research and understanding why it has happened. Generally, if little is known about an issue, a qualitative approach might be more useful.

Based on the outlined objectives of this study and the description mentioned above, quantitative approach was used in this research in order to gain as thorough an overview of the research area as possible. The quantitative research approach required to develop a basis to establish background knowledge about energy management and its needs for Gaza Strip construction industry. In this type of research, relevant published data from periodicals, journals, conference proceedings, web-based knowledge and other research reports were revised to establish the study survey.

## 3.3 Research strategy

Many authors (Biggam, 2008; Saunders et al., 2009) review some of the available strategies that could be considered for a project depending of their ability to answer the research questions and meet the objectives of the study. Singh (2006) defined research strategy as " a generalized plan for a problem which includes structure, desired solution in terms objectives of research and an outline of planned devices necessary to implement the strategy ". Saunders et al. (2009) defined research strategy as " the general plan of how the researcher will go about answering the research questions". Different research strategies can be applied to achieve the research objectives systematically, these involve gathering data, use of statistical techniques, interpretations and drawing conclusions about the research data (Saravanan, 2011). Both Yin (2003) and Saunders et al. (2009) acknowledged that although various research strategies exist, there are large overlaps among them and hence, the important consideration would be to select the most advantageous strategy for a particular research study. Yin (2003) recommended that a particular research strategy has to be selected based on three conditions; the type of research question, the extent of control an investigator has over actual behavioral events and the degree of focus on contemporary or historical events.

The structured questionnaire may be the most common tool of data collection in surveys strategy to obtain opinion, views, and facts (De Vaus, 2002; Naoum, 2007). Synodinos (2003), Naoum (2007) and Brinkman (2009) have proposed several advantages and disadvantages of questionnaires tool, as follows:

❖ ***<u>Advantages of the questionnaire tool;</u>***

1. Simple and straightforward method to study attitudes, motives, beliefs or values, and may be adapted to collect general information;
2. The answer can be more accurate ;
3. The response rate is relatively high (approximately 60-70 %);

4. It is also considered as a low cost and less time consuming technique especially, if there are time constraints, as well as anonymity if it is required;
5. Researchers have used this technique widely in most of the previous studies for data collection.

❖ ***Disadvantages of the questionnaire tool;***

1. There could be misunderstandings or ambiguities during the completion;
2. There may be no chance to elaborate on an answer which could give additional or new information to the research;
3. The data may be affected by the respondents' characteristics such as, lack of seriousness or responses based on desirability rather than real facts.

Due to the lack of existing data and research in energy management issue in local construction industry, it was felt that a survey is the best strategy for this study as it can provide needed information and some insight into the current energy management situation in local construction industry. Paper survey (a structured questionnaire) was used as a method for data collection because of its lower cost and time and convenience to include large sample size. Questionnaire was the basic tool used commonly in similar studies (e.g. De Groot et al., 2001; Rohdin et al., 2007; Bassioni et al. 2010; Shi et al., 2013; Kostka et al., 2013; Brunke et al., 2014; etc.). In addition, visits with interviews with experienced persons working in academics and management positions in the construction and energy sectors were used to collect data that serves the questionnaire design. Table (3.1) below provides detailed description of the methodologies used in several studies about many fields related to this study subject.

## 3.4 Research process

Research process consists of series of actions or steps necessary to effectively carry out the research and the desired sequencing of these steps (Kothari, 2004). This study objectives were achieved by completing four main successive phases, each phase involves several tasks. These four phases are:

1- **First phase :** Information gathering.
2- **Second phase:** Research design
3- **Third Phase:** Main data collection and analysis
4- **The fourth phase:** Writing the research report

The following sections provide detailed description for theses mentioned phases and the tasks conducted in each phase to realize this study objectives.

### 3.4.1 First phase : Information gathering.

Information gathering phase is an important part of the research process which provides a foundation or context about the study and for constructing the questionnaire. It aims to identify the study problem, questions, objectives and to collect the main variables and information related to this study objectives including energy management awareness features, application requirements, drivers, barriers and the best activities to save energy during project construction. This phase covers several tasks, which are:

a. Formulating the research problem;
b. Extensive literature review;
c. Preliminary interviews;

These three tasks have been discussed in detail in the next sections.

1. **Formulating the research problem.**

Fellows and Liu (2008) stated that "an initial study is an essential stage in the identification of a topic has not already been researched, or if previously studied and reported, needs further investigation". Hence, the first step of this research process was to undertake some initial studies, which can provide the means for identifying the research issue, problem, defining the research questions and can help in establishing the objectives of the research. Clearly, there are many different sources of research ideas (e.g., observing everyday behavior or reading scientific journals).

With the help of this study supervisor, the researcher realized that energy issue is an essential problem facing all sectors in Gaza Strip. On the other hand, they found that construction industry as one of the most important economic sectors in Gaza Strip, practiced without any considerations relating to environmental issues especially, which related to efficient energy use, saving and management. In the same line, as a kind of proactive environmental management in construction companies, energy saving and management is very new for many Palestinian industries. Forth more, very little or no investigations and studies have been pointed out the problems, components or strategies that are related to energy management in local construction sector. All of the mentioned reasons encouraged the researcher to focus on this subject and to propose an objectives that can help to initiate efficient energy use in local construction projects, focusing on the construction phase as it is mainly related to the construction contractors who have formed this study sample. Accurately, to increase the understandings about the energy and energy management problems in local construction sector, the researcher perceived the importance to understand how energy management are defined and practiced. and what are the key drivers, obstacles and activities that affect how it can successfully adopted.

In the last decade, an increased number of studies have been published in academic literature focusing on several aspects of environmental practices in construction industry. In fact, the studies on energy use and management in local construction projects are very limited. Therefore, to overcome the shortage in data related to energy management, the researcher studied different related terms commonly used in scientific papers, textbooks, annual reports and the media. Eventually, energy management can be interpreted by several concepts and terms used in previous studies. On the basis of this conclusion, data collection and validation of this study contents was based on studies concerning several terms related to this study subject area, such as energy efficiency, environmental management, carbon management, sustainable construction, green construction, as well as a set of guidelines for managing sustainable development.

In the same line with this assumption, Sustainability Victoria (2007) and Apeaning (2012) used energy management and energy efficiency as the same meaning. Russell (2005) argued that, energy efficiency refers to practices and standards set forth in an energy management plan. In their review, Cagno et al. (2013) considered energy efficiency and energy conservation improvement to be analogous. Fisher and Bristow (2009) indicated that energy savings and sustainability go hand in hand. In addition, sustainability, sustainable development and sustainable construction are intertwined (Khalfan et al., 2015). Shelbourn et al. (2006) and Suliman and Omran (2009) reported that, the term “green” is associated with different concepts such as “energy-efficient” and “sustainable” which share the aim of creating environmentally-friendly products and services. Mohanty (2012) proposed green energy as the main tool for achieving an efficient energy. WCED (1987) and Fisher and Bristow (2009) stated that, sustainability is often synonymous with “green building”, “high performance building” and “energy efficiency”. In addition to becoming synonymous, “green” and “sustainable” also have become broad, all-encompassing terms for many environmental concepts. Examples of terms used to describe portions of the larger green/sustainable movement include “environmentally responsible”, “energy-efficient”, “resource renewable”, “recyclable”, “carbon neutral,” (Hoff, 2008).

Based on the aforementioned discussion, the researcher identified and clarified the basic meaning of the concepts included in each research objective and several sources were reviewed in the problem formulation stage to identify and clarify the basic components of the study concepts. Research employed an extensive review of relevant theories and literature related to energy management, energy efficiency, sustainable construction, green construction, environmental management and etc. This study may fill up the research gap by measuring the level of energy management awareness and application in local contracting companies and clarifying behind drivers, barriers and more efficient energy saving activities.

Table (3.1): Methodologies adopted in previous studies related to sustainability and energy issues.

| Author (Published date) | Area- Country | Industry Sector | Main Subject | Data measurement | Data collection method | Data analysis method |
|---|---|---|---|---|---|---|
| De Groot et al. (2001) | Netherlands | Chemical, Basic metals, Metal products, Horticulture, Food, Paper; construction & materials and textiles | Energy saving | 5-points Likert scale | Questionnaire survey | * Average score<br>* Regression analysis |
| UNEP (2006) | Bangladesh, China, India, Indonesia, Mongolia, Philippines, Sri Lanka, Thailand and Vietnam. | Cement, Chemicals, Ceramics, Iron & Steel, Pulp & Paper | Energy efficiency | 6-points Likert scale | * Questionnaires survey<br>* In-depth interviews | *Average score |
| Christoffersen et al. (2006) | Denmark | Manufacturing industry | Energy management | 2-points answer (Yes or No) | Telephone survey | * Participation ratio<br>* Factor analysis |
| Rohdin et al. (2007) | Sweden | Foundry | Energy efficiency | 3-points Likert | Questionnaire survey | *Average response rate |
| Qi et al. (2010) | China | Construction sector | Green innovation in construction | 5-points Likert scale | Structured questionnaire | * Factor analysis<br>* Regression analysis |
| Bassioni et al. (2010) | Egypt | Construction industry | Environmental Management Systems | 5-points Likert scale | Structured questionnaire | *Mean scores |
| Bond and Perrett (2012) | New Zealand | Commercial property sector | Sustainable Development | 10 -points Likert scale | * Online survey<br>* Structured interview | *Average score<br>* Total responses percentage |

Table (3.1): Methodologies adopted in previous studies related to sustainability and energy issues. "Continued"

| Author (Published date) | Area-Country | Industry Sector | Main Subject | Data measurement | Data collection method | Data analysis method |
|---|---|---|---|---|---|---|
| Liu et al. (2012) | Taicang, China | Electronics, Pharmaceutical industry, Chemical fiber, Machinery manufacturing, Textile and dyeing, Chemicals, Paper making and Food processing. | Energy saving | 2-points assessment (Yes or no) 5-points Likert scale | Questionnaires survey | *Participation ratio * Factor analysis * Regression analysis |
| Liu (2012) | Fujian, China | Chemical fibers, Raw chemical materials, Chemical products, Metal smelting and Pressing electrical machinery and equipment | Carbon management | 5-points Likert scale | Case study, Semi structured interviews | *Frequency analysis |
| Cagno and Trianni, (2013) | Italy | Primary metals, Textiles, chemical, Petro-chemical and Manufacturing | Energy efficiency | 4-points Likert scale | case-study approach (Semi structured interviews, investigation) | *Average score |
| Apeaning and Thollander (2013) | Ghana | Iron, Steel, Aluminum, Food, Plastics and Chemicals | Energy efficiency | 3-points Likert | Semi-structured interview | *Average score |
| Trianni et al. (2013) | Ital | Metal manufacturing | Energy efficient technologies: | 4-points Likert scale | * Multiple case study * Semi structured interviews *Questionnaires | *Average score |
| Hwang and Ng (2013) | Singapore | Construction sector | Green construction | 5-points Likert scale | * Questionnaire survey * Interview | *Mean value |

Table (3.1): Methodologies adopted in previous studies related to sustainability and energy issues. "Continued"

| Author (Published date) | Area-Country | Industry Sector | Main Subject | Data measurement | Data collection method | Data analysis method |
|---|---|---|---|---|---|---|
| Samari et al. (2013) | Malaysia | Construction sector | Green Building | 4-points Likert scale | Questionnaire survey | * Mean<br>* Correlation analysis |
| Venmans (2014) | Belgium | Ceramic, Cement and Lime | Energy efficiency | 4-points Likert scale | * Case studies<br>*Interview<br>* Questionnaire | * Mean score<br>* Principal component analysis. |
| Brunke et al. (2014) | Sweden | Iron and Steel industry | Energy conservation measures, energy management practices and energy services | 5-points Likert scale | * Questionnaire<br>* Follow-up telephone interviews | *Percent rank |
| Liu et al. (2014) | Japan | Food processing, Chemical, Iron & steel, Electronics and others | Energy saving activities | 2-points assessment (Yes or no)<br>5-points Likert scale | Questionnaires survey | * Participation ratio<br>* Factor analysis<br>* Regression analysis |
| Abd Elkhalek et al. (2015) | Egypt | Construction industry. | Environmental management | 5-points Likert scale | Questionnaires | Monte Carlo test |

2. **Extensive literature review.**

A combination of secondary data and primary data are required to complete the study (De Vaus, 2002; Naoum, 2007). Secondary data were collected from journals, articles and books using university library and internet. Primary data was collected by a structured questionnaire and discussions with the supervisor, academicians and experts in the construction and energy sectors. Literature review involves reading and appraising what other people have written about the subject area. Naoum (2007) identified two purposes of literature review, as follows:

- ✓ **First,** it seeks systematic reading of previous information which is related to the area of investigation. The gathered information will develop issues and ideas and should drive to the next important stage, namely, research design;
- ✓ **Second,** the literature review helps the researcher to improve his research study by giving him some insights into how he can design his own study.

For the purpose of the research work presented in this thesis, latest literatures in terms of thesis (MS and PhD), journal articles, conference proceedings, web materials, reports and books on industrial energy efficiency and management principles, drivers, barriers and energy savings activities have been compiled. This study literature review was prepared in order to include the following main issues:

1. Review local energy situation including energy sources and its main problems;
2. Discuss the different impacts of the construction industry activities on energy consumption ;
3. Introduce an overview of the energy management concept and its related principles;
4. Describe the importance of energy management during onsite construction;
5. Discuss the major worldwide activities and strategies for industrial energy management focusing on construction industry;
6. Explore the dominant driving forces and barriers to adopt energy management strategies in construction industry;
7. Review research methodologies, data collection and analysis methods conducted by other researchers in the same subject area.

All these issues have contributed to the understanding of the research topic concerned with adopting of energy management in local construction workplaces. Furthermore, reviewing these literature issues have allowed the researcher to formulate a research process that can lead to substantial results or rather achieve the research objectives. Once the survey concepts have been established, they need to be translated into observable variables (Brancato et al., 2006).Thus, the literature review was done to collect a comprehensive list of the statements and variables relevant to the study objectives, which were frequently cited in previous studies and can be used to achieve objectives of this study.

In this stage, researcher compiled several lists of common criteria to measure the degree of awareness and practice of energy management and the factors which may inhibiting and driving energy management adoption in different industries and construction sector, and the main activities to save energy during construction process. Previous published researches provide a rich resource to address these important study statements/variables and help in several decisions as to what statements/variables to be included and how to measure them, apparatus to use, what procedures to use, and so on. Appendix (C) provides detailed description of the collected statements/variables and related references for each one. This initial set of the statements/variables were set out in a specific list to be reviewed later. Flexibility was allowed to let the researcher to modify the statements/variables, as they came to mind. Table (3.2) below summarizes the number of the initial statements\variables collected and number of the references from which these statements/variables delivered. This table includes the collected statements/variables related to the features, requirements, drivers, barriers and activities to adopt energy management and efficiency in different industries.

Table (3.2) : Summary of the initial set of the collected variables\statements.

| Obj. No. | Objective description | Statements/Factors | No. of collected factors | No. of references used |
|---|---|---|---|---|
| 1 | To assess the local contractors level of awareness about energy issues and energy management in construction industry. | Energy management awareness features | 13 | 28 |
| 2 | To identify the degree of practice of energy saving and management during construction process in local contracting firms. | Energy management application requirements | 26 | 18 |
| 3 | To explore the major drivers enhancing the local contractors to adopt energy management during project construction. | Energy management adoption drivers | 53 | 24 |
| 4 | To identify the key barriers to the implementation of energy management in local contracting companies during the project construction. | Energy management adoption barriers | 159 | 29 |
| 5 | To pinpoint the contractor best activities to reduce energy consumption during the project construction . | Energy management activities to save energy | 86 | 21 |

However, due to the complexity of the construction process it is impossible to identify all relevant statements\variables. In addition, energy management is initiating concept in local construction industry and the environmental issues need to be managed before proposing any technical change. For that, in this study, the researcher focused exclusively on managerial, strategic, organizational and regulative factors which are related to decision making to practice energy management in local construction sector. Understanding the nature of these factors will accelerate the spread and adoption of energy management during the construction process. Limiting the study to managerial, strategic, organizational and regulative factors will permit both broad and in-depth analysis of the influence of these factors on the development of energy performance of local construction contractors. In addition, construction industry was the main focus of this research, but due to the lack of energy management knowledge and experience within this sector, the researcher also took the opportunity to learn from other industrial sectors. Table (3.1) listed above, presents different studies with different industries conducted in many areas in the world.

The followings parts explain the deep investigations on literature review sources that have been conducted to collect the major concepts and variables\statements related to the research objectives ;

***First objective: To assess the local contractors level of awareness about energy issues and energy management in construction industry.***

This objective have been proposed to understand and reveal the awareness level of energy management in local construction companies. However, after revising several studies and researches, the researcher found that there is a lack of systematic method or measurement tools to be used in identifying the awareness level of energy management. The primary tactic adopted in this research was proposed to use multiple sources of energy and energy management related definitions, outcomes and concepts which considered as the core concepts of the environmental and energy management issues and have been presented frequently in the environmental, sustainability, energy and energy management studies. The researcher called these collected concepts and definitions as energy management awareness features and then look for the respondents view about it. Based on responses obtained, local contractors awareness evaluation related to energy management issue can be identified according there understanding and knowledge about the suggested statements "features" which are a major concepts related to energy and energy management in industry. Thirteen features were collected initially to measure the level of local contractors awareness about energy management concept. These features presented in Table (C.1) of Appendix (C). These features obtained from the concepts included in the studied researches in literature review and hadn't studied as a separated concept in these studies.

***Second objective: To identify the degree of practice of energy saving and management during construction process in local contracting firms.***

Christoffersen (2006) and Ates and Durakbasa (2012) proposed a method to measure the industrial sector degree of practice of energy management by developing a list of minimum requirements to split the studied companies into two categories, those companies with energy management practices and those without. Minimum application requirements refers to the major practices in the firm which are related to sustainability, environmental and energy management and demonstrate the application level of these issues in the firm. In the line with this conclusion, Liu et al. (2014) argued that the breadth of a company's' energy saving and management adoption efforts may be represented by the establishment of energy saving goals and management procedures, as well as actual actions. Taking into account the specific characteristics of Gaza Strip, a list of energy management application requirements was prepared based on various investigations in several studies and discussions with energy and construction experts. Thus, a comprehensive set of twenty six requirements was developed and obtaining local contractors deployment degree of the proposed requirements can reflect practice level of energy management in the firm. Table (C.2) in Appendix (C), lists the basic requirements of any energy management program as collected during literature review.

***Third objective:* To explore the major drivers enhancing the local contractors to adopt energy management during project construction.**

Reddy and Assenza (2007) indicated that drivers are supportive tools that promote private investment in energy efficiency and facilitate the spread and adoption of the energy management strategies/practices in industry. Many drivers to adopt energy management practices were collected from different industries. These drivers have different natures and sources which make it to affect the local contractor with different levels to adopt energy management during project construction. Table (C.3) in Appendix (C), lists the fifty drivers to adopt energy management in industry and construction sectors which have been collected during literature review.

***Fourth objective:* To identify the key barriers to the implementation of energy management in local contracting companies during the project construction**

Even though improved energy management becomes of an increased importance for construction industry, a number of barriers exist which inhibits deployment of the potential for improved energy management. Weber (1997) highlighted the sources of the barriers for energy efficiency which may include persons, patterns of behavior, attitudes, preferences, social norms, habits, needs, organizations, cultural patterns, technical standards, regulations, economical interests and financial incentives, etc. Based on previous clarification, the barriers in this study include the factors that inhibits the spread of energy management concept/practices in local construction sector and the factors that prevents the local contractors to successfully adopt proposed energy management strategies during construction process. Table (C.4) of Appendix (C), provide initial list of the 159 major barriers to adopt energy management in different industries and construction sector as collected during literature review.

***Fifth objective:* To pinpoint the contractor best activities to reduce energy consumption during the project construction**

This part of the study aimed to present a set of activities that may be implemented and sustained over time and thought to be an essential guideline, particularly for decision makers in local construction sector to reduce energy use, increase energy efficiency and enhance the spread of the energy management concept in local construction sector. These activities clarify the most efficient means that can be adopted by local contractor to be more energy efficient and to save energy consumption and its related environmental impacts during onsite construction.

It is important to recognize that energy conservation technical measures alone are not enough. Gorp (2004) argued that, one might employ the best technology with the most efficient systems but without proper energy management. However, energy management is a modern concept for the local construction industry and to obtain the fastest means to spread it, this study has attempted to demonstrate the energy management activities from the firm's internal, organizational and managerial points of view. Providing the organizational and managerial decisions and techniques to save energy will make the local construction contracting companies more energy efficient and practicing more energy management.

The focus of this study discussion was on activities related to decision making into the construction contracting companies, but specific and specialized technical activities, materials or construction methods to save energy during project construction weren't considered widely. Although there were some technical activities used in this study, but they are general concepts requiring managers decision to be employed. Table (C.5) in Appendix (C), lists 86 major managerial or strategic activities to save energy in industry and construction sectors as collected during literature review.

### 3. Preliminary interviews

A large number of the statements\variables related to each objective were collected during the literature review process and at the time of conducting this research it was not known if the statements\variables that have been theorized or found to be important in other countries were also important in the construction industry in Gaza Strip. Not all of the collected statements\variables in the initial lists may be consistent with the conditions and circumstances surrounding Gaza Strip from economic level, the type of projects, geographical region and occupation factors, which experienced Gaza Strip. Accordingly, statements\variables to be selected for the study should be commensurate with the nature of construction projects and problems in the Gaza Strip.

Rattray and Jones (2007) considered consultation with experts in the field as an important step in generating the items to be included in the questionnaire. Since they provide experience based information from actual field specific practice and their advice requires little qualification or validation, early experts discussions with construction practitioners has been widely used in construction studies to confirm the appropriateness of the factors (Meng, 2011). Creswell (2014) stated that, unstructured interviews can help to cause some preliminary issues to surface so that the researcher can decide what variables need further attention. The use of experts revision will allow the factors to be more describing and will facilitate the search for more accurate results. In addition, Chung (2004) and Israel and Chaudhary (2014) emphasized that preliminary experts interviews are considered invaluable sources in practical research which can provide good initial feedback for the survey designer about the questionnaire contents. Preliminary unstructured interviews without a planned sequence of questions for the experts were conducted to confirm, refine and rephrase the factors derived from the literature (Cavana et al., 2001).

A domain expert is simply an individual or group of individuals who are considered knowledgeable on the system under study (Chung, 2004). Israel and Chaudhary (2014) stated that "experts are agents or specialists who have extensive experience or knowledge of a particular topic, field issues, questionnaire design and testing, and cultural perspectives of the survey". In practice, they are people can apply their theoretical understandings and extensive practical experience in subject matter and survey development. Several researchers proposed many suggestions about the number of the experts to be involved in developing the questionnaire items and revising the questionnaire. Ader et al. (2008) revealed that, four to five experts are adequate to judge the survey items. Brancato et al. (2006) suggested perform experts review with three to six experts. Babonea and Voicu (2011) indicated that expert panels are usually a small group of people (3 to 8) that critique the questionnaire contents from multiple perspectives. Zohrabi (2013) reported that, the researcher might ask two or three experienced experts to review and comment on the interview. Olson (2010) suggested that, the number of expert reviewers tends to be small, ranging from two or three expert to over 20 reviewers. Israel and Chaudhary (2014) suggested that a panel of three to four experts and a survey designer are considered appropriate to review the questionnaire contents. Slottje et al. (2008) indicated that, the number of experts for most studies lie between 6 and 12 and at least six experts should be included in revising the questionnaire contents. However, DeMaio and Landreth (2003) provided four reasons why experts might differ in the number and types of problems that they identify on survey questions. These include the time each expert spent on the task, their expectations about the task, their perceptions about what makes "good" or "bad" questions, their experience or training in conducting evaluations of questionnaires, and whether the review is conducted collaboratively or individually. Therefore, all stages of this study questionnaire construction have involved experienced individuals in the study related aspects and their number have been varied in each stage according to their availability and desire to participate in the study review. In addition, the time available to the researcher and duration taken in the interviews, directly affected the number of the experts involved in each stage of this study. In addition, accuracy required in each stage outcomes also affected the number of the experts to be involved.

Based on the previous discussion, and the long interviews periods required to review and refine the large number of the collects factors from the initial review, this study stage engaged six experienced persons in different fields to review the collected statements/variables. Two of them were academicians in construction management, one energy expert and three project managers from different engineering associations. The academicians and the project managers have more than 20 years of experience in construction management and the energy experts have more than 15 years in energy aspects.

This process involved revision and verification of all statements/variables collected from literature review in the context of construction industry in Gaza Strip. First, all findings from the literature review were reviewed and verified by the researcher and the supervisor before conducting the preliminary experts review. Then, the experts were first briefed on the purpose of the study and its proposed objectives and they were asked to give their opinions on the collected statements\variables and to highlight most important of them when performing the research survey. Several face-to-face meetings and discussions were conducted with each expert to fine tune the preliminary lists of the collected statements\variables and to validate the results of the literature review which resulted in preparation of the basic data to be used in this research to achieve the identified objectives. Saunders et al. (2009) suggested that the face-to-face interactive process can encourage the interviewee to share opinion and previous experience. Six factors were considered in this study such as the pattern of the interview, listening, questioning, paraphrasing, probing and non-verbal behavior (Cavana et al., 2001). All experts suggestions have been kept to prevent losses of any essential information and to give the researcher time to focus on given comments and follow up suggestions. Four main outcomes from the experts review process for the initial lists of the collected statements/variables were obtained in this study, as follows:

- ✓ **First outcome:** Experts revision would provide in-depth discussions for assessing the selecting of the statements/variables needed for the questionnaire survey. Additional statements/variables, which the researcher may have overlooked during the literature review would emerge or become relevant. It is a more flexible way of obtaining information.
- ✓ **Second outcome:** During revision phase ambiguity in collected statements/variables could be clarified by the experts immediately.
- ✓ **Third outcome:** It would enable the researcher to identify the grouping system for the statements\variables to be included according to its nature.
- ✓ **Fourth outcome:** It will help the researcher to seek for and to gather more data by identifying relevant documents on energy management .

The suggestions of the experts with researcher experience were included and summarized in Tables (D.1) to Table (D.5) in Appendix (D). The comments received from each of them were reviewed and a number of revisions involving deleting, adding, merging or modifying many statements\variables made to develop the final version of the factors list. All suggestions and revisions were then considered to provide a base for constructing draft and final research questionnaire which will be discussed in the second phase of this research (research design phase). General conclusion of the experts review processes performed on the initial collected factors were presented in Table (3.3) .

Table (3.3): Experts review processes performed on the initial factors collected for study.

| Obj. No. | Objective description | statement/variable description | No. of collected factors | Process | No. of factors under process | No. of the final factors |
|---|---|---|---|---|---|---|
| 1 | To assess the local contractors level of awareness about energy issues and energy management in construction industry. | Energy management awareness features | 13 | Selected | 8 | 10 |
| | | | | Merged | 0 | |
| | | | | Modified | 2 | |
| | | | | Deleted | 3 | |
| | | | | Added | 0 | |

Table (3.3): Experts review processes performed on the initial factors collected for study "Continued"

| Obj. No. | Objective description | statement/variable description | No. of collected factors | Process | No. of factors under process | No. of the final factors |
|---|---|---|---|---|---|---|
| 2 | To identify the degree of practice of energy saving and management during construction process in local contracting firms. | Energy management application requirements | 27 | Selected | 3 | 17 |
| | | | | Merged | 7 | |
| | | | | Modified | 6 | |
| | | | | Deleted | 1 | |
| | | | | Added | 5 | |
| 3 | To explore the major drivers enhancing the local contractors to adopt energy management during project construction. | Energy management adoption drivers | 53 | Selected | 17 | 26 |
| | | | | Merged | 25 | |
| | | | | Modified | 4 | |
| | | | | Deleted | 4 | |
| | | | | Added | 6 | |
| 4 | To identify the key barriers to the implementation of energy management in local contracting companies during the project construction. | Energy management adoption barriers | 156 | Selected | 12 | 31 |
| | | | | Merged | 88 | |
| | | | | Modified | 11 | |
| | | | | Deleted | 43 | |
| | | | | Added | 2 | |
| 5 | To pinpoint the contractor best activities to reduce energy consumption during the project construction . | Energy management activities to save energy | 86 | Selected | 18 | 33 |
| | | | | Merged | 41 | |
| | | | | Modified | 11 | |
| | | | | Deleted | 32 | |
| | | | | Added | 1 | |

### 3.4.2 Second phase: Research design

Research design is " a statement of the object of the inquiry and the strategies for collecting the evidences, analyzing the evidences and reporting the findings " (Singh, 2006). It is an action plan for obtaining answers to the questions being studied in the study (Naoum, 2007). Choosing an appropriate research design is crucially important to the success of the study. The decisions taken at this stage of the research process do much to determine the quality of the conclusions that can be drawn from the research results. The primary priority is to guarantee that the research maximizes the chance of realizing its objectives. Research design helps to plan of the methods to be employed for collecting the relevant data and the techniques to be adopted for their analysis, so as to pursue the objectives of the research in the best possible manner. Research design must concentrate on the research questions; determine what data are required, and how the data are to be analyzed. Also, take into account the logic that links the data collection and analysis to yield results then to conclusions (De Vaus, 2002; Tayie, 2005).

The data needed for this research was about energy management awareness features, application requirements, drivers, barriers and best activities in a particular sector (local construction sector), with a particular type of firms (contracting companies) and for a specified position of respondents (managers and decision makers). Therefore, this type of purpose can be characterized as “descriptive” as it serve as direct sources of valuable knowledge concerning human behavior and reflect facts about the subject matter (Tayie, 2005). During this phase, the researcher performed four activities, which are :

1. Sample design and sampling procedures;
2. Format of the questionnaire questions;
3. Data measurement technique;
4. Questionnaire design;

The following sections provided detailed description for each process mentioned above.

**1. Sample design and sampling procedures**

Sample design is a definite plan for obtaining a sample from a given population. It refers to the technique or the procedure the researcher would adopt in selecting items for the sample (Kothari, 2004). Sample design of this research covered the following items :

a) Research population;
b) Sampling unit;
c) Sampling frame "source list": consists of names of all items of the population, and from which the sample should be selected. Parameters of interest in sampling which clarifies the specific population parameters of interest considered while determining the sample design;
d) Sample size;
e) Sampling procedures.

**a) Research population**

Research population refers to the entire group of people, events or things of interest that the researcher wishes to investigate in a study (Sekaran and Bougie, 2010). It is the set of units that the sample is meant to represent (De Vaus, 2002). From many construction practitioners working in construction sector in Gaza Strip, this study focused its investigations on the main contractors only as they have the greatest influence and the main responsibility of environmental, cost and energy management during project construction process. For the purpose of this study the population consisted of all construction contracting companies from the first three classes which working in Gaza Strip and have valid registration till the end of November 2014 according to the Palestinian Contractors Union (P.C.U) records. The following reasons have driven the researcher to choose the construction sector to be studied:

- **First:** In recent years, like other industries, the construction industry has been under pressure in order to adopt environmental friendly approaches and environmental responsibility is nowadays seen as important competitive advantage.

- **Second:** Its relevance to the local economy in Gaza Strip, both in terms of number of companies, number of employees, turnover, etc.;
- **Third:** Construction sector officials in Gaza Strip don't take energy related issues into account in their strategies, polices and plans..
- **Fourth:** Energy costs and energy saving strategies related to construction sector hadn't discussed extensively and in-depth in previous studies conducted about this industry in Gaza Strip.
- **Fifth:** The traditional construction practices deployed at present in local construction industry makes the energy management implementation very difficult and it need more development .
- **Sixth:** Improving the performance of the construction sector will likely improve the performance of most other economic sectors as well as increase the quality of life for Gazan people.

Construction works are a core activities of the construction projects which include all aspects of construction activities from site preparation and management to project completion. Hence, the basic focus of this study was on construction phase that require high costs for energy sources to be completed. In addition, its activities generally generate many pollutants and have a greater impact on the environment than other industry activities as these activities use several materials and employing various construction equipment and machines which consume a large amount of different types of energy. In the same time, construction process is the main concerns of the local contractors and directly affected by the company management decisions, especially which related to environmental issues.

**b) Sampling unit**

A decision has to be taken concerning a sampling unit before selecting sample. The sampling unit is "the element or a set of elements that is available for selection in some stage of the sampling process" (Zikmund et al. 2009; Sekaran and Bougie, 2010). As mentioned earlier, Palestinian Contractors Union (P.C.U) have a specified classification system for the registered contracting companies which includes five classes ranges from first to fifth classes depending on the company performance in several fields. The first class is the best class where fifth class is the last class. Therefore, as energy management is somewhat advanced and sophisticated subject, and to get realistic results the researcher addressed this study towards the top contracting companies of the first, second, and third classes according to the P.C.U classification system. Each of these classes is homogeneous and have the same particular characteristic of interest according to P.C.U system. Table (3.4) below lists the number and percentages of valid contracting companies from the considered classes which form the population of this research. Accordingly, the sampling unit in this study was the first three classes of the valid contracting companies working in Gaza Strip.

The decision to limit the scope of the study only to these three classes has been taken for following main reasons:

1) Contracting companies from these three classes are usually undertake most of the large projects given to local contractors; hence, impact of any improvement achieved will significantly contribute to the overall improvement of the local construction industry's performance.

2) Contracting companies from these three classes have better organizational, human and financial capabilities than contractors at lower levels, hence, they are better suited for starting efforts related to energy issues development and improvement in the industry.

3) Mainly there is a significant gap between those contractors and the lower classes contractors in terms of capacity and management capabilities; thus, it was thought that this will create difficulty in generalizing the research result.

4) Lower classes contractors were excluded from the study specifically because they are very few in number (only 29 contractors from fourth class and 22 contractors from the fifth class were registered by P.C.U when this research was conducted).

Table (3.4): Valid first three classes contracting companies according to P.C.U classification.

| Class | First class | Second class | Third Class | Total |
|---|---|---|---|---|
| Registered No. | 73 | 66 | 40 | 179 |
| Percentage | 41% | 37% | 22% | 100% |

#### c) Sampling element

Sampling element usually represents the respondent in survey research and refers to the object about which or from which the information is desired and about which inferences are to be made (Malhotra and Birks, 2006) . The appropriate sampling element selection for this study have been based on Pickett (1998) study conclusion, which has reported that the current and future success of an enterprise is a reflection of the effectiveness of the senior team, their vision and leadership, and combined knowledge and skills of the organizations workforce. This suggests that the identification of environmental success criteria that will enable an organization to meet the demands of the future can be assumed to be the key responsibilities of senior managers such as senior business executives or managing directors. In this study, the questionnaire was sent to projects managers and site engineers in contracting companies from the first three classes asking about energy management situation in their companies, the population was of contracting companies from the first three classes and not of projects managers. Siniscalco and Auriat (2005) stated that, the source from which the data are to be collected is not necessarily identical to the population definition.

Subsequently, in this context, experienced projects managers and site engineers working for the contracting companies in Gaza Strip were chosen as the sampling element (respondents), as they are responsible for decision making regarding corporate and project objectives. The main reason to survey these groups from contracting organizations was to get the realistic picture about efforts done in order to introduce energy management practices within the construction projects. In addition, these staff were targeted because they fell into the category of respondents that could give reliable information based on the purpose of this study. Projects managers and site engineers refer to individuals who are experienced in the managerial and construction activities and with highest authority to handle day-to-day activities with the aim of delivering the project also accountable for a managing energy aimed at providing an efficient and healthy environment. The perceptions of projects managers and site engineers can help other interested stakeholders to have a clearer understanding of what constitutes company success in the direction of the studied subject. Therefore, their role in the whole process is quite crucial and it was important to survey to capture their perceptions

#### d) Sampling frame

Sampling frame is a list of elements from which the study sample should be selected (De Vaus, 2002; Zikmund et al. 2009). Malhotra and Birks (2006) concluded that the discrepancy between the population and the sampling frame in some instances, is small enough to ignore. In same line with this conclusion, the sampling frame of this study have represented the investigated population (first three classes of the contracting companies working in Gaza Strip). Hence, the sampling frame in this study was the P.C.U directory listing data about the valid firms in an local construction industry.

#### e) Sample size

Study sample is a subset of population selected to participate in a research study and its size refers to the number of the elements to be included in a study, which can be individuals, groups or organizations (Tayie, 2005; Zikmund et al. 2009). The aim of determining an adequate sample size is to estimate the population prevalence with a good precision (Naing et al., 2006). It is extremely rarely possible to conduct full population surveys so that, a sample can be chosen from the study population that is commonly referred to as the 'target population' (Malhotra and Birks, 2006). The most advantage of using sample is that it is less time and less costly than collecting data from all of the population. Otherwise, the disadvantage of using sample is that the selected sample may not adequately representative of the population and the results obtained from it cannot be generalized (Tayie, 2005; Marczyk et al., 2005)**.** The principles of statistical sampling which guarantee a representative sample are employed for economy and speed (Fellows and Liu, 2008).

Several factors can influence the size of the required sample for a study, including the purpose of the study, population size, sample sizes used in similar studies, the risk of selecting a "bad" sample, and the allowable sampling error and resource constraints (Malhotra and Birks, 2006; Israel, 2013). A statistical calculation approach have been used in this study to calculate the required sample size. The following formula was used to determine the sample size of unlimited population (De Vaus, 2002; Israel, 2013; Creative research system, 2014).

$$SS = \frac{Z^2 \times \mathrm{P} \times (1 - \mathrm{P})}{C^2}$$

The variables included in this formula can be described as follows:

- ✓ **SS = Sample Size.**

Refers to the number of respondents to be included in the study. In this study, it represents the number of the contracting companies to be surveyed by selecting one individual (projects manager or site engineer) from each company to fill the questionnaire.

- ✓ **Z = Z Value**

Known as Z statistic for a level of confidence and equals to 1.96 for 95% confidence level (i.e. significance level of $\alpha = 0.05$). As with most other research, a conventional confidence level of 95% was assumed in this research (Naing et al. 2006; Israel 2013; Creative Research Systems, 2014).

- ✓ **P = Percentage picking a choice "*Degree of variability*"**

The *degree of variability* in the attributes being measured, refers to the distribution of attributes in the population, which explains the estimated proportion of an attribute that is present in the population (Czaja and Blair, 1996). According to Israel (2013), when determining the sample size for a given level of accuracy, the worst case percentage picking a choice (*p*) should be assumed. Its value taken as 50% or 0.5 as it would lead to a larger sample size (Naing et al. 2006). Based on these assumptions, the sample size was computed using p= 0.5 expressed as decimal,

- ✓ **C= Confidence interval, also known as *"Margin of error"* , *" Level of precision"* or *"Sampling error"*.**

It is the range in which the true value of the population is estimated to be, expressed as decimal (Israel, 2013). Generally, the confidence interval is the plus or minus figure usually reported in newspaper or television opinion poll results (Creative research system, 2014). The general rule relative to acceptable margins of error (a precision ) in categorical data research is 5% (Bartlet et al., 2001; Israel, 2013). However, its value can be increased when a higher margin of error is acceptable or may decreased when a higher degree of precision is needed (Bartlet et al., 2001). According to the need to find balance between the level of precision, resources available and the value used in other similar researches, a confidence interval (*C*) of 8% was assumed for this study to calculate the sample size. The following reasons justify this assumption:

- Naing et al. (2006) supposed that a larger margin of error (e.g. >10%) can be used if there is a resource limitation, and the population size is small ( lower than 500). These constraints may include budget, time, personnel, and other resource limitations (Bartlet et al., 2001). In this study, the targeted population is 179 which is less than 500 as described previously. On other hand, since the target group in this study are the project managers and site engineers, the possibility to access them need greater access time and effort because they are very busy and the difficulty to arrive to them to fill the questionnaire, in the same line this study had a deadline should be met, which means getting less than accurate results

- In addition, De Vaus (2002) concluded that, if the sample are broken up into a number of relatively small groups the sampling error (and thus the confidence interval) for those groups will be relatively high. In this study, the population grouped under three groups ( firs, second and third classes of contracting companies) and the sample was selected by stratified random sampling method as will described latter.

- Preston (2012) found that the error margin in a confidence interval which used in the used formula does not include the effects of other errors such as the error from poorly recorded data, that will lead to additional estimation error. Hence, the margin error in this research was increased to consider other errors may result from sampling method, data recording and editing and data analysis errors ad etc.

- On the other hand, margin of error and hence sample size affected by the data analysis type, in which, when descriptive statistics are to be used, e.g., mean, frequencies, then nearly any sample size will suffice ( Israel, 2013).The descriptive analysis considered as the main data analysis used in this study.

- Several recent research conducted in construction industry of Gaza Strip, and which were very similar to this study have used a margin of error (confidence interval) equals to 8% such as Falouji (2014) and Zaiter (2014).

On the basis of the mentioned reasons, sample size for this study can be calculated as follow:

$$SS = \frac{1.96^2 \times 0.5 \times (1 - 0.5)}{0.08^2} = 150$$

The above sample size formula is valid if the calculated sample size is smaller than or equal to 5% of the population size ($n/N \leq 0.05$) If this proportion is larger than 5% ($n/N > 0.05$), we need to use the formula with finite population correction (Bartlet et al., 2001; Naing et al. 2006), using the following formula:

$$New\ SS = \frac{\text{ss}}{1 + \frac{ss - 1}{pop}}$$

Where;

New SS = Corrected sample size.
pop = Population size “179”.

In this study, the population was 179, and the ratio between the obtained sample size and the population equals to 0.84 (150/179) which is larger than 0.05, then corrected sample size for finite population can be calculated as follows:

$$New\ SS = \frac{150}{1 + \frac{150 - 1}{179}} = 82$$

The sample size formulas used above provide the number of responses that need to be obtained in study. Israel (2013) reported that, many researchers commonly increased the sample size about 10% to 30% , to compensate for persons that the researcher is unable to contact and for nonresponse. De Vaus (2002) proposed to use sample size that is 20 % larger than the expected end up sample. Thus, the number of distributed questionnaires can be substantially larger than the number required for a desired level of confidence and precision. So that, in this study, 100 questionnaires to be distributed to construction contracting companies working in Gaza Strip.

**f) Sampling procedure**

A sample design "sampling procedure" refers to the technique or the procedure the researcher would adopt in selecting items for the sample (Kothari, 2004). Its goal is to obtain a sample that properly mirrors the population it is designed to represent (De Vaus, 2002). Several criteria should be considered to select representative sample. In this study, the population consisted of three groups which are the first, second and third groups, then, more complicated sampling method should be adopted to select the questionnaire respondents. De Vaus (2002) reported that, when the population from which a sample is to be drawn does not constitute a homogeneous groups, then stratified random sampling technique can be applied so as to obtain a representative sample from each of these smaller homogeneous groups (strata). The elements within each stratum should be as homogeneous as possible (Malhotra and Birks, 2006). This homogeneity helps researchers to reduce sampling error (Tayie, 2005). In addition, Zikmund et al. (2009) pointed out that, in stratified random sampling, a subsample is drawn using simple random sampling within each stratum. This method is one of the random sampling techniques and yields precise estimation and more accurate than those produced by simple random sampling; particularly, when the sampling frame is available in the form of a list (Kothari, 2004). It can provide adequate, representative and homogeneous respondents within each class under study (Singh, 2006). According to Love et al. (2013) there are two main benefits can be obtained from using stratified sampling method, which are:

1. Ensuring the adequate and representative respondents with in each class under study is acquired.
2. Ensure that the respondents within the same class are homogeneous.

The discussion above directed this study researcher to adopt the stratified random sampling method to select a representative sample from the three groups of the contracting firms which constitutes the study population.

Malhotra and Birks (2006) defined stratified sampling as "a two-step process in which the population is partitioned into sub-populations, or strata. The strata should be mutually exclusive and collectively exhaustive in that every population element should be assigned to one and only one stratum and no population elements should be omitted. Next, elements are selected from each stratum by a random procedure". De Vaus (2002) described the steps needed to stratify a sample randomly to be represented in its correct proportion, as follows

1. Select the stratifying variable ( contractor class in this study);
2. Divide the sampling frame into separate lists - one for each category of the stratifying variable (lists of valid contracting companies in each class have been obtained from the P.C.U);
3. Draw subsample of each list by simple random sampling method. Each subsample should be proportionate to the size of that stratum (group) in the population

To select the sample in this study, the researcher followed the method of proportional allocation under which the sizes of the samples from the different strata are kept proportional to the sizes of the strata as described by Kothari (2004). That is, if Pi represents the proportion of population included in stratum *i (*number of contracting firm under each class*)*, and *n* represents the total sample size (targeted respondents), the number of elements selected from stratum *i* is *nPi*. The next step includes the selection of each stratum elements based on random sampling technique. For that, a list of the data related to the registered valid contracting companies from the first three classes was obtained from the Palestinian Contractors Union (PCU) and the respondents were selected based on the following steps:

- ✓ **First step:** All the target contractors were distributed to construct three groups with three classes; first, second and third classes. Malhotra and Birks (2006) observed that, in random sampling "probability sampling" it is possible to pre-specify every potential sample of a given size that could be drawn from the population,
- ✓ **Second step:** The sample of the contracting companies to be targeted to fill the questionnaire had chosen randomly "by chance" from each group according to its percentage of the total target population.

Table (3.5) describes the sampling numbers and percentages used in this study. The number of the returned questionnaires and the valid questionnaires number and percent are presented in this table .

Table (3.5) : Sampling description and distribution

| Class | Population | Class proportion to population | Distributed questionnaires | Returned questionnaires | Valid respondents | Proportion of valid respondents |
|---|---|---|---|---|---|---|
| First class | 73 | 41% | 41* | 33 | 30 | 39.5% |
| Second class | 66 | 37% | 37 | 34 | 30 | 39.5% |
| Third class | 40 | 22% | 22 | 19 | 16 | 21% |
| Total | 179 | 100% | 100 | 86 | 76** | 100% |

*Distributed questionnaires for each class = (73/176) x100

** Final valid questionnaires number accepted for analysis and discussion = 76.

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**2. Format of the questionnaire questions**

The statements/variables collected in the first stages of the study should be translated into a form that respondents understand (Brancato et al., 2006). The forms of the questionnaires questions can be classified into three types: (Tayie, 2005; Singh, 2006; Biggam, 2008; Brinkman, 2009; Zohrabi, 2013)

1. Closed form or restricted questions type;
2. Open form or unrestricted questions type;
3. Mixture of closed and open questions.

Closed form questions are used when specific answer are needed, in which a number of alternative answers are provided from which respondents are to select one or more of the answers (Biggam, 2008). This type of questions are easier for people to respond to and facilities the tabulation and analysis of data. It also improves the reliability and consistency of the data (Singh, 2006). The major disadvantage of closed questions is that researchers often fail to include some important responses as the respondents may have an answer different from those that are supplied (Tayie, 2005).

On the other hand, an open question is one for which respondents formulate their own answers (De Vaus, 2002). It can provide freedom for the respondents in answering questions and the chance to provide in-depth responses which give much richer information. However, in open questions type, people need more time to answer them, and processing the data also takes longer time and effort (Tayie, 2005; Brinkman, 2009; Zohrabi, 2013). Generally, closed questions can provide quantitative or numerical data and open questions provides qualitative or text information (Zohrabi, 2013).

On the base of the objectives of the study in hand and the advantages and disadvantages of each question format type, the researcher decided to use closed questions, which are more likely yield the data needed for the research. In addition, the respondents in this study came from managerial positions and they were very busy as they have had many works to do, so they may not willing to put aside an extensive amount of time to provide answers when open forms questions used.

**3. Data measurement**

Malhotra and Birks (2006) defined measurement as "the assigning of numbers or other symbols to characteristics of objects according to certain pre-specified rules " while scaling which may be considered an extension of measurement have been defined as "the generation of a continuum on which measured objects are located ". De Vaus (2002) reported that, a scale is a composite measure of a concept and a measure composed of information derived from several questions or indicators. Traditionally, the scale (level) of measurement of a variable is fundamental in the choice of statistical methods when we come to analyze the data (De Vaus, 2002; Elliott and Woodward, 2007). There are four primary scales of measurement: nominal, ordinal, interval and ratio (Tayie, 2005; Malhotra and Birks, 2006; Singh, 2006; Sekaran and Bougie, 2010). Each type offers the researcher progressively more power in analyzing and testing the validity of a scale (Zikmund et al, 2009). In order to be able to select the appropriate method of analysis, the level of measurement must be understood.

- **Nominal level**

A nominal scale is a figurative labelling scheme in which the numbers serve only as labels or tags for identifying and classifying objects (Malhotra and Birks, 2006; Zikmund et al., 2009). Nominal scale is the simplest scale of measurement for data collection and analysis (Brinkman, 2009). In this scale of measurement, the nominal variable is one where the different categories have no set rank-order as it makes no sense to say that the categories can be ordered from low to high in some sense (De Vaus, 2002). When a nominal scale is used, each number is assigned to only one object, and each object has only one number assigned to it Malhotra and Birks (2006). This scale often called qualitative scales, and measurements made on qualitative scales were called qualitative data. For that, this scale has been used in the first part of questionnaire to classify the respondents on the base of several characteristics such as the respondent education level or experience and the firm experience and classification and etc.

- **Ordinal level**

The term rank order often used to describe an ordinal scale which allow things to be arranged in order based on how much of some concept they possess. In fact, ordinal variable is one where we can rank-order categories from low to high (Zikmund et al., 2009). In other words, ordinal scale help in determining whether an object has more or less of a characteristic than some other object, but it cannot specify in numeric terms how much difference there is between the categories ( De Vaus, 2002;  Brinkman, 2009; Sekaran and Bougie, 2010). Thus, an ordinal scale indicates relative position, not the magnitude of the differences between the objects (Malhotra and Birks, 2006). For example, when a variable has five responses arranged from low to high and one respondent select the second answer and another person select the third answer, we can say that there is a difference between the two respondents and the second respondent select higher response for the variable than the first respondent but this difference magnitude can't determine.

In this study, the difference quantity between the respondents awareness and application levels and their perceptions about the drivers, barriers and activities related to energy management subject can't be measured. Accordingly, the scale used in all parts except the first part of the questionnaire can be considered as ordinal scales. The responses assigned in ascending order to indicate the relative extent to which the respondents possess some characteristic. The numbers assigned to the scale (1, 2, 3, 4, 5) do not indicate that the interval between the scales are equal, nor they indicate absolute quantities (Naoum, 1998). With ordinal variables, they can indicate the relative ordering of an individual's response to an item and can be converted to a rank when compared with other items scores (Rattray and Jones, 2007) .

The last two scales of measurement are interval and ratio scales, which hadn't used in this study as they were not appropriate to measure the used data and variables and they can't achieve the study objectives. An interval scale contains all the information of an ordinal scale, but they also capture information about differences in quantities of a concept. Numerically equal distances on the scale represent equal values in the characteristic being measured (Malhotra and Birks, 2006). A ratio scale represent the highest form of measurement which possesses all the properties of the nominal, ordinal and interval scales, and, in addition, an absolute zero point. Thus, in ratio scales we can identify or classify objects, rank the objects, and compare intervals or differences (Malhotra and Birks, 2006; Zikmund et al., 2009)

Several scaling techniques have been used in formatting survey studies. Ranking (rank order) and rating scaling are the major types of scaling techniques that have been used interchangeably, even though there is a distinction. Under ranking scales (or rank order scale) we make relative judgements against other similar objects. This technique is appropriate in many instances when researchers are interested in the relative perception of several concepts or items or to measures people's preferences on a list of related items (Tayie, 2005). The respondents under this method directly compare two or more objects and make choices among them to put the objects in some form of order (Kothari, 2004; Sekaran and Bougie, 2010). De Vaus (2002) reported that ranking format requires respondents to rate the importance or strength of an item relative to the way other items in the set have been rated (e.g., "Please rank each of the following items in order of importance, from the #1 most important item through the #10 least important item"). In addition, this format provides answers that indicate the relative rather than the absolute importance of items.

From other side, rating scales are the most common alternative to ranking scales. They also gather information about respondent preferences and opinions, but their design is slightly different. When we use rating scales, we judge an object in absolute terms against some specified criteria without reference to other similar objects (Kothari, 2004).This scale involves a set of responses where the alternative answers are ordered from low to high and the respondents need to indicate where between the low and high extremes lies their attitude (e.g., "Please rate each of the following items on a scale of 1-10, where 1 is 'not at all important' and 10 is 'very important') (De Vaus, 2002). Accurately,, rating scales are used to measure most behavioral concepts (Sekaran and Bougie, 2010). Brancato et al. (2006) preferred to use the rating scale with a limited number of points when the researcher seeks to locate a respondent's opinion, the favorability of an item, the frequency of behavior and etc,. In general rating scale involves qualitative description of a limited number of aspects of a thing or of traits of a person (Kothari, 2004). In surveys, the most commonly used question types are rating scale questions. This is where respondents are asked to indicate their personal levels on things such as agreement, satisfaction or frequency.

Rating scales were the most appropriate scaling format that can be used in this study questionnaire as the researcher required to obtain the respondents' perceptions an attitudes toward the statements individually rather than ranking them within a group, and hence, they were asked to judge each statement in absolute terms against some specified criteria such as awareness or application levels of each statement used in the first and second objectives of this study regardless the other statements included in each group. This option allows respondents to give the same rating to more than one item if they wish. Consequentially, several statistical methods can be used to rank each group statements. Based on the former description, the questionnaire parts regarding the respondents perceptions were formulated to ask the respondent to indicate their rating on each statement as follows:

1. **First objective "awareness level about energy management":** Indicate at what level you are agree on the accuracy of each one of the following statements which are related to energy issues.

2. **Second objective "practice level of energy management":** Indicate at what level your company applying each of these requirements in its activities and projects.
3. **Third objective "drivers to adopt energy management":** Select efficiency level of each one of the stated drivers.
4. **Fourth objective "barriers to adopt energy management":** Select agreement level of each one of the stated barriers
5. **Fifth objective "activities to save energy during project construction":** Select usefulness level of each one of the listed activities to save energy.

This study survey questionnaire aimed to collect quantifiable data. This required the adoption of an appropriate rating scale to measure attitude responses. Likert scale is the most widely used rating scale to measure attitudes which involves providing a statement that reflects a particular attitude or opinion. Respondents indicate their level of agreement or disagreement on a predefined number of scale points for carefully constructed statements (DE Vaus, 2002; Malhotra and Birks, 2006; Zikmund et al., 2009). The response categories in Likert scales have a rank order, but the intervals between values cannot be presumed equal and then, this scale should be considered ordinal scales to measure of a person's attitude and should be analyzed accordingly (Lee, 2006). Likert scale has several advantages. In general, it is simple and easy to construct and administer, and respondents readily understand how to use the scale, making it suitable for Internet surveys, mail, telephone or personal interviews (Kothari, 2004; Malhotra and Birks, 2006). This scale is more reliable and its reliability can be assessed by easy methods (De Vaus, 2002). On the other side ,there are several limitations of the Likert scales. One important limitation which coming from its nature as ordinal scale is that, with this scale, we can simply examine whether respondents are more or less favorable to a topic, but we cannot tell how much more or less they are. In addition, Likert scale takes longer to complete than other itemized rating scales because respondents have to read and fully reflect upon each statement. (Malhotra and Birks, 2006; Lee, 2006).

With reference to its benefits, a five-point Likert scale was used in this study questionnaire to give some degree of flexibility of choice to reflect the intensity of respondent views, so that, the respondents asked to rate the each statement included in the questionnaire. Brancato et al. (2006) reported that, the number of response categories can influence the quality of the data as both too few and too many categories can cause errors. Questions with a high number of response categories can cause respondent fatigue and inattention, resulting in ill-considered answers. Also, too few categories respondents may have difficulty in finding one which accurately describes their situation. Lee (2006) supposed that the best number of Likert scale points is fewer than seven points. Johns (2010) confirmed that, data from Likert items becomes significantly less accurate when the number of scale points drops below five or above seven. In fact, the common number of points for Likert scale is five points scale. The reason why five has become the norm is probably because it can provide a compromise for the different ideas about the enough points of Likert scale and this number of points will make things manageable for respondents choice since Likert scales with few number of means measuring only direction rather than also strength of opinion and when the number of scale points increased than five or seven few people will have a clear idea of the difference between consequent points.

Although some controversy exists as to whether a neutral point should be offered in Likert scale, this study questionnaire adopted Likert scale with odd number of points and involved a neutral point which represents no opinion or average opinion. Rattray and Jones (2007) concluded that an odd number of points allows people to select a middle option, and if it is not available, the respondents will be forced to choose a response, which may lead to respondent annoyance, increase non-response bias and risks of data quality from choosing a level of commitment that the respondent do not have. De Vaus (2002) and Brancato et al., (2006) stated that, in self-administered questionnaires it is desirable to offer the middle position. Lee (2006) highlighted that existence of a middle alternative in scale is good because it represents the best description of some respondents' feelings. If not included, people place more frequently the responses in the positive side of the scale, due to the general willingness to be "nice" rather critical.

Each answer point in used Likert scale has taken a number and verbal label to suit each objective requirements. The verbal labels appeared in questionnaire while the researcher preserved the numbers to be used in data analysis. Providing a verbal label over each point better ensures that everyone interprets the points similarly reducing measurement error. Also, few people express their opinions in numerical terms so numbers have less meaning to respondents. It is best not to mix labeling words with numbers as numbers may confuse respondents or have unintended meaning so it is best to remove numbers from the scale (Lee, 2006). The proposed Likert midpoints labels given to number three "third answer" in this study questionnaire.

In summary, Table (3.6) provides a description of the Likert scale points used in the this study questionnaire, which have been arranged in ascending order to measure the strength respondents' attitude. The respondents were required to answer the questions according to actual situations that they had experienced in their companies and on projects they were working on or had recently completed.

Table (3.6): Likert measurement scale adapted in the questionnaire

| No. | Section title | Measurement scale | | | | |
|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 |
| 1 | Respondent and company general information. | Nominal scale | | | | |
| 2 | Local contractors level of awareness/knowledge of energy management. | Strongly disagree | Disagree | Neutral | Agree | Strongly agree |
| 3 | Local contractors degree of practice of energy saving and management in the construction projects. | Never applied | Rarely applied | Sometimes applied | Often applied | Always applied |
| 4 | The major drivers enhancing local contractors to adopt energy management during project construction . | Ineffective | Low effective | Moderate effective | High effective | Very high effective |
| 5 | The key barriers to the implementation of energy management in contracting companies of Gaza Strip | Strongly disagree | Disagree | Neutral | Agree | Strongly agree |
| 6 | The best energy management activities to save energy during project construction | Usefulness | Low useful | Moderate useful | High useful | Very high useful |

## 4. Questionnaire design

There are several guides available on how a questionnaire should be designed (e.g. Naoum, 2007; Singh, 2006; Lee, 2006; Fellows and Liu, 2008). In general, the questions should be short and simple, avoid scientific terms, ask for only one piece of information at a time and avoid unnecessary negatives in the sentence structure. In this research, a structured questionnaire was used as a tool for data collection to satisfy the stated objectives. Quantitative design questionnaire with closed questions including nominal and ordinal of five point Likert scale were used in order gather, analyze and interpret the data.

The contents of the research questionnaire in this study were constructed based on the followings:

- ✓ Review of pertinent literature;
- ✓ Several interviews with the thesis's' supervisor and many energy and construction experts to obtain different opinions and thoughts which can be useful for creating questions;

- ✓ The experience of the researcher and some colleagues "engineers" in energy and construction management in Gaza Strip were utilized to construct the study questionnaire.

Several versions of the questionnaire "drafts" were formulated to be investigated and discussed with a range of experienced individuals including the research supervisor, the researcher colleagues and other experts who were encouraged to write comments and alterations on each version of the modified questionnaire. Finally, the final questionnaire was prepared after several times of revisions, modifications and piloted, and then this final questionnaire version was distributed and filled by the proposed sample from the local contracting companies. There were many activities performed in the research process to construct the study questionnaire. The following sections provide a description of these activities that were carried out at each stage of the questionnaire design process.

**1) Draft questionnaire design**

Brancato et al. (2006) indicated that, preparing draft questionnaire is the first step after the identification of the variables to be included in the study, the questionnaire plan and form , the questions format and the sample size and sampling procedures. As described earlier, the data that has been collected from literature review was subjected to several preliminary interviews with different experts to examine and review the initial collected statements\variables that related to the study objectives. As shown earlier in Table (3.2) and Table (3.3), these interviews have produced the following statements\variables to be included the study questionnaire, initially:

1. To measure the local contractors level of awareness as required in first objective of this study, a total of 10 statements " energy management awareness features" were accepted from the 13 statements collected from the previous works and studies.
2. To identify the practice level of energy management in local contracting companies as specified in the second objective, a total of 17 statements "energy management application requirements" were generated from the 26 statements that have been collected from different sources.
3. To indicate the drivers for energy management adoption in local contracting companies as designated in the third objective of this study, 26 factors "drivers" on overall were confirmed from the 53 factors collected from many previous sources.
4. To pinpoint the barriers to energy management adoption in local contracting companies as compiled in the fourth objective, 31 factors " barriers" were verified from the 159 collected factors that have been included in previous sources.
5. To specify the most appropriate activities to save energy during project construction as demonstrated in the fifth objective, 33 factors " energy saving activities" were kept from 86 factors proposed in several previous sources.

The obtained data and the statements/factors retained from the previous procedure in Table (3.3) were used to construct the initial draft questionnaire "first version". Several aspects have affected this draft preparation such as, the nature of the research and the stated objectives, literature searches, researcher personal experience and the preliminary interviews with experts. This questionnaire has consisted of closed questions and involved the relevant data and questions needed for this study. The first draft of this study questionnaire was established to include the following six sections:

- **Section 1 :** Respondent and company general information.
- **Section 2 :** Local contractors level of awareness/knowledge of energy management.
- **Section 3 :** Local contractors degree of practice of energy saving and management in the construction projects.
- **Section 4:** The major drivers enhancing local contractors to adopt energy management during project construction.
- **Section 5:** The key barriers to the implementation of energy management in the contracting companies of Gaza Strip.
- **Section 6:** The best energy management activities to save energy during project construction.

The draft questionnaire was formatted in a sequence and a form that can achieve the study objects, and three types of questions have been proposed as identified by Brancato et al. (2006), as follows:

1. **Demographic questions:** which are fact based information required from the respondent and have been provided to distinguish the main groups of respondents in a survey for later analyses.
2. **Knowledge questions:** these also fact based information questions to test the respondent's knowledge and degree of application of energy management and saving in construction.
3. **Opinion questions:** These questions seek to measure subjective opinions rather than facts. Several questions were provided in this questionnaire to identify the respondents opinions about energy management adoption drivers and barriers and best energy saving activities.

The first version of the draft questionnaires with its basic ideas were discussed with the study supervisor for his advice. In addition, to attain an increased success rate of the survey, prior meetings were held with a group of experienced individuals in statistics, construction and energy field to judge and assess the quality of draft questionnaire items and its content. This first draft was subjects to several pretesting evaluations to prepare the semifinal questionnaire as described in the following steps.

#### 2) Questionnaire pretesting

Pretesting is a broad term that incorporates many different methods or combinations of methods (Scheuren, 2004). Zikmund et al. (2009) defiend a pretest as " it is a very descriptive term indicating a small-scale study in which the results are preliminary and intended only to assist in design of a subsequent study". A pretest of the questionnaire, and a check for errors in the measurement instruments and equipment will help determine if significant problems are present (Kothari, 2004; Tayie, 2005). Scheuren (2004) and Brancato et al. (2006) described two major categories of questionnaire pretesting, which are pre-field and field pretesting. Pre-field methods are generally used during the preliminary stages of questionnaire development. In general, pre-field testing methods are applied under "Laboratory conditions" which refer to an observational environment which may totally or partially differ from the actual field conditions. On other hand, field methods are those used to evaluate questionnaires tested under field conditions which means that, the interview is carried out in a way very similar to the subsequent fieldwork and the majority of the conditions mirror the real survey situations (Brancato et al., 2006). Combining pre-field and field methods provides an evaluation of broad scope (Scheuren, 2004). For that, several trials of pre-field testing with different experts in construction, energy and statistics were conducted in this research before conducting the field testing "pilot study. The following sections provide in-depth description about the pretesting methods conducted in this study;

**1) Questionnaire pre-field testing**

There are many ways to perform the pre-field pretest of a questionnaire. Several researchers recommended that, expert reviews should be conducted during the initial phase of the questionnaire pre-field testing process (Brancato et al., 2006; Olson, 2010; Yan et al., 2012). Olson (2010) demonstrated two primary goals of an expert review which were to reveal problems with a survey instrument so that they can be remedied prior to going into the field or to sort items into groups that are more or less likely to exhibit measurement errors. Experts pretesting makes it possible to detect problems that could not be identified through the other techniques (Babonea and Voicu, 2011). Expert reviews generally produce only qualitative information, typically in the form of judgments about whether an item has a problem and, if so, what kind of problem (Yan et al., 2012). Pre-field testing should be viewed as iterative process involved trial run with a set of research professionals aimed to perfect the questionnaire to its intended purpose (Synodinos, 2003; Zikmund et al. 2009). Face-to-face interview is a common technique proposed by Saunders et al. (2009), which can be used to acquire extensive feedback from the respondent on the whole of the questionnaire. These face-to-face interviews with many experienced individuals were undertaken in this study to identify flaws in the questionnaire, the adequacy of the questions, and to assess appropriateness of layout, tone and content, structure and questionnaire format. The flexible and semi-structured format was used in the interview session. The face-to-face interview is also a valuable technique for checking inconsistencies and obtaining detailed feedback regarding the questionnaire (Tayie, 2005; Saunders et al., 2009).

In this study, to be sure a study questionnaire is adequately designed, it was subjected to pre-field testing. The entire test process was conducted in three phases "runs" with experts to point out fundamental problems on the content, wording or design of a questionnaire. In each testing trial, the questionnaire is revised, modified then new pretesting trial preformed again. It is clear that these three pretest are beneficial as any potential errors or mistakes in the actual data collection can be minimized before disseminating the questionnaire for the pilot survey. The first run was performed to review the draft version of the questionnaire " first version" that has prepared in the previous step, according to this revision results a semifinal questionnaire was prepared. The second run was conducted to review the semifinal questionnaire and then modified to the final pre-field testing to prepare the final questionnaire to be tested in field as will described latter "pilot study".

Chung (2004) and Israel and Chaudhary (2014) described that, the individuals to be involved in the questionnaire review should have extensive experience in the study topic, field issues and questionnaire design. Accordingly, experienced persons in energy and construction aspects and statistician were contacted to review the revised versions in each run. The number of the experts to be included in each run of pre-field pretesting for the questionnaire preparation and review have been discussed earlier in this study. The number of the experts involved in each run of pretesting depend on several factors which will be declared in each run as follows:

- **First pre-field testing run: Semifinal questionnaire design**

Expert reviews are frequently used as a first method of evaluating draft questionnaires (DeMaio and Landreth., 2003). A series of interviews were conducted with this study supervisor, industry experts and academicians to refine the survey questions and contents in order to reflect the actual energy management situation in local construction industry. Each expert was asked about the suitability of visual design of the questionnaire and to identify any problems in the questionnaire format questionnaire flow, the questions clarity and any alternative forms or contents of questions to work best.

On the basis of the previous discussion and as indicated by Slottje et al. (2008), eight experts from different specializations were involved in revising the draft questionnaire "first version" and part of them included in the preliminary interviews which were conducted previously. Four of the expert reviewers were employed at different contracting organizations; one was employed at energy authority, one was employed at construction client and two was employed at academic institutes "universities". Clearly, several factors caused the number of the experts to be increased in this stage when compared with the preliminary interviews stage which have involved six experts only. Higher number of contacted experts were interested to participate in draft questionnaire review and the length of the interviews in this stage has been shorter than the length of preliminary interviews, due to the reduced number of the involved statements\variables in this draft questionnaire. In addition, higher accuracy was required in the results of this stage because it can establish the questionnaire to be investigated and tested in and to reduce the modification in the subsequent phases.

All experts examined the same questions in the first draft developed by the researcher. The experts conducted the reviews individually. The pre-test instructed respondents to fill out the questionnaire and report back any feedback they had on it. This pretests assisted the researcher to refine the draft questionnaire and it can be restructured and various items may have to be rewritten.

Table (3.7) provides detailed description of the first draft questionnaire review process. The semifinal questionnaire was prepared taking into account the preceding modifications on the draft version. This semi-final questionnaire were subjected to the subsequent run of pre-field pretesting which were conducted by twelve experienced persons and academics from local construction contracting companies and educational institutes. Statistics specialist has checked the questionnaire to make sure that it was logical and that the collected data can be easily fed into the statistics program (For example SPSS).

❖ **Second pre-field testing run**

After preparing the semifinal questionnaire, it was tested to evaluate its contents. Six experts of several specializations were required and available to perform this run of pre-field testing namely, two from contracting organization; two academician in university, one statistician and one working in construction consultancy organization. Some of those experts may be involved in the previous run of pretesting. The experts knowledge and expertise in construction and research design made their feedback regarding improvements to the shortcomings identified in the questionnaire helpful. As mentioned earlier in this study, the number of the involved experts satisfied the general requirements by different researchers (Tayie, 2005; Brancato et al., 2006; Slottje et al., 2008; Olson, 2010; Babonea and Voicu, 2011)

The researcher asked the involved participants to identify if the questions are well understandable or not, also to find out and describe any problem that may raise in filling the questionnaire and proposed alternative solutions. As a result, participated respondents made several valuable suggestions which were helpful in improving the quality of the questionnaire. This test identified some problems in the questionnaire visual design, poor wording and ambiguous questions which could be misinterpreted by the participant. As a result of pre-testing, certain difficult words were replaced with simple words and options for some questions were modified. Specific ideas were gained prompting some changes to the sentence structures and wording in order to provide more clarity to the intended original purpose of the questions. Accordingly the semifinal questionnaire version was amended to be reviewed in the next run.

❖ **Third pre-field testing run**

The third run of the pre-field pretesting was conducted to finalize the experts revision process so that, another group of different experts from those participated in the second run, reviewed the modified version of the pretested questionnaire some of them may be involved in first run of pretesting or in preliminary. The questionnaire was modified according to the modifications suggested by the experts involved previously. In general, participant experts examines the questionnaire from various perspectives. However, pretest process practitioners distribution and detailed suggestions and outcomes of this process are depicted in Table (3.7).

**2) Field pretesting "Pilot study"**

Before preparing the final version of the questionnaire, the semi draft questionnaire resulted from the final phase of the previous pre-field pretesting must be evaluated as a whole. Field testing of the questionnaire is necessary to check the effectiveness of the instrument before the actual data collection starts. As far as possible, this pretesting should be conducted to assess the whole questionnaire under actual survey conditions and with people who resemble those to whom the questionnaire will finally is conducted (De Vaus, 2002). Thus, the second type of questionnaire pretesting methods that should be performed called as field pretesting or pilot study which is a crucial stage in the development and assessment of survey questions by testing the questions in the field (Brancato et al., 2006). Malhotra and Birks, (2006) defined pilot testing as "testing the questionnaire on a small sample of respondents for the purpose of improving the questionnaire by identifying and eliminating potential problems". This pilot testing includes assessing the validity of each question (whether the question is capturing information it is intended to measure to meet the goals and objectives of the study) and analyzing the various aspects of questionnaire as a whole (Israel and Chaudhary, 2014). In addition, Ader et al. (2008) highlighted that, pilot survey provides feedback on errors, unexpected problems, and respondents' willingness to participate in the survey.

Naoum (2007) argued that, pilot study provides a trial run for the questionnaire, which will be used to test the quality, clarity, time scale and bias of the questionnaire by testing the wording of the questions, identifying ambiguous questions, irrelevant information, testing the technique that used to collect the data, etc. It is worth noting that, pilot study or field pretest of a questionnaire often solves most problems with closed ended questions (Tayie, 2005). There is no prescribed sample size for a field test and various researchers suggest sample sizes from 10–25 (Malhotra and Birks, 2006) to 20–50 (Tayie, 2005). Otherwise, Israel and Chaudhary (2014) asserted that the decision for the sample size in pilot study is made by the researcher based on available time and budget to carry out the field test and larger sample sizes are recommended to achieve more robust testing results of the questionnaire Self-administered questionnaires approach commonly used in the pilot test for research.

In this study, it was difficult to conduct pilot study separated from the data collection phase for many reasons such as, limited time available for research, difficulty to obtain required participants in short period as study involved respondents from managerial positions and etc. On the other hand, pilot testing is connected with long process of collecting and analyzing data in order to be performed. Accordingly, the researcher selected 20 copies of a filled questionnaires that have been collected on the field during the actual phase of data collection. These copies were analyzed by SPSS (V.22) in order to test its validity and reliability which are discussed in the next section. This process ensures the chosen methods are suitable, valid, reliable, effective and free from problems or errors. If any serious problem found from the analysis results in questionnaire validity or reliability subsequently, the questionnaire should modified before producing and distributing the new improved version again

Table (3.7): Results of the questionnaire pretesting.

| Expert no. | Position and "Experience" | Organization | Comments/suggestions /recommendations |
|---|---|---|---|
| **First run pre-field pretesting** | | | |
| Expert 1 | Managing director "22 years of experience" | Contractor | ▪ Removed the second question about gender type of the respondent from the first section.<br>▪ Changed the measurement scale of the sixth question in first which is related to organization size by reducing this scale.<br>▪ Arabic language of some items should be revised to clearer for the respondents.<br>▪ Combined two barriers for energy management adoption into one factor as it had the same meaning and impact which are: *"Management is concerned about the time required to adopt energy management practices"* and *"Tight project duration"* |
| Expert 2 | Projects manager "16 years of experience" | Contractor | ▪ Scale of the energy management activities need to be revised and changed so as using usefulness as base of this scale.<br>▪ Rephrased some questions such as:<br>- The driver *"Increased energy prices"* should be modified to be *"Rising energy prices in local market"*<br>- *The activity "Governmental energy regulations related to consumption and management"* should be modified to be *"Applying the governmental regulations requirements related to construction energy use"*<br>▪ Improved the layout of the questionnaire, so as the section related to energy management adoption barriers comes in the last position of the questionnaire. |
| Expert 3 | Site engineer "9 years of experience" | Contractor | ▪ Definitions related to energy management should be provided in the cover letter.<br>▪ Researcher contact information in should be inserted in the cover letter.<br>▪ Construction works term can be used instead of onsite construction term so as, management effects on the study can be understood more. |
| Expert 4 | Operation manager "15 years of experience" | Energy authority | ▪ Adding the world " quantity" in each statement related to energy cost to be "energy cost and quantity"<br>▪ Using energy efficiency in several places instead of using energy management. |

Table (3.7): Results of questionnaire pretesting. " Continued"

| Expert no. | Position and "Experience" | Organization | Comments/suggestions /recommendations |
|---|---|---|---|
| Expert 5 | Quantity surveyor "16 years of experience" | Contractor | ▪ Two drivers should be merged in one driver which are "*Establish a competitive advantage"* and *"Improved reputation / recognition"* to form the driver *"Improvement of the company competitive advantage and reputation as a result of adopting energy management in its projects"*<br>▪ Some of the items of energy management adoption derivers field were deleted because they were repeated and were ambiguous such as: *"Type of project donor/client (Local, international)"* |
| Expert 6 | Contracts management engineer "14 years of experience" | Client | ▪ Instructions are not clear.<br>▪ The barrier *"Management finds production more important"* should be removed because there was barriers with the same concept.<br>▪ The application requirement *"The company has a stable system to reward and punish workers for energy-related issues"* should be modified to be *"My company introducing incentives for the employees to efficient energy use during construction works"* |
| Expert 7 | Ph.D. in Construction engineering and management "30 years of experience" | University | ▪ Revised scale range for second and third part.<br>▪ Deleted different items from the drivers part.<br>▪ Items DEM4 & DEM 14 were modified in English language .<br>▪ Detailed description before each section of the questionnaire should be added. |
| Expert 8 | Ph.D. in sustainable architecture "26 years of experience" | University | ▪ Cover letter should include clear description of the scientific terms used in the questionnaire such as, sustainability, GHG emissions, energy efficiency and etc.<br>▪ English language of the some words in the questionnaire were modified .<br>▪ The application requirements *"Energy audit and accounting"* and *"Analyzing onsite energy uses"* can be merged together to be one factor which is *"My company conducting energy audit and accounting for its construction works to record and report energy consumption and saving opportunities"* |

Table (3.7): Results of questionnaire pretesting. " Continued"

| Expert no. | Position and "Experience" | Organization | Comments/suggestions /recommendations |
|---|---|---|---|
| **Second run of pre-field pretesting** | | | |
| Participant 1 | Project manager "16 years of experience" | Contractor | ▪ The wording of the energy management application requirements was changed by adding the word "tools" to the awareness programs.<br>▪ Arrangement order of the items in Arabic version of the questionnaire should be consistent with its arrangement in English. |
| Participant 2 | Site engineer "11 years of experience" | Contractor | ▪ Modified the English wording of some items in the different fields of the questionnaire such as *AEM4, AEM9, AEM3, AEM14, AEM25, SEM6, SEM7, BEM12*.<br>▪ The word "client" was added to the driver DEM13 to include all main participants of construction industry in Gaza Strip. |
| Participant 3 | Statistician " 19 years of experience" | Bureau of statistical | ▪ Proposed coding method for the variables used in the study to shorten the data analysis.<br>▪ Removed the numbers on each scale label. |
| Participant 4 | Construction site supervisor engineer "17 years of experience" | Consultant | ▪ Changed the statement in the activity AEM 26 from " Lower material used during construction" to become "Practicing of onsite construction methods leading to lower material used"<br>▪ Modified the Arabic wording of different items such as SEM3, SEM 7, SEM8, DEM22 and BEM19. |
| Participant 5 | Ph.D. in renewable energy & architectural design " 22 years of experience | University | ▪ The unit of measurement of the respondent and the firm experience "years" should be removed in the first part questions, Q2 and Q4 as it exists in the answers.<br>▪ The unit of measurement of the question Q8 "Million Dollars" should be provided in brackets in the question. |
| Participant 6 | MSc in construction project management " 8 years of experience | University | ▪ Modified the energy management feature AEM6 by adding the statement "competitive advantage" in brackets after the item.<br>▪ Modified the activity SEM19, by adding detailed description |

Table (3.7): Results of questionnaire pretesting. " Continued"

| Expert no. | Position and "Experience" | Organization | Comments/suggestions /recommendations |
|---|---|---|---|
| **Third run of pre-field pretesting** | | | |
| Participant 7 | Projects managers "24 years of experience" | Contractor | ▪ The questionnaire fully clear and applicable, and can be distributed to the proposed respondents. |
| Participant 8 | Quantity surveyor "16 years of experience" | Contractor | ▪ The questionnaire fully clear and applicable, and can be distributed to the proposed respondents. |
| Participant 9 | Contracts managemen t engineer "14 years of experience" | Client | ▪ The questionnaire fully clear and applicable, and can be distributed to the proposed respondents. |
| Participant 10 | Ph.D. of construction engineering and managemen t"27 years of experience" | University | ▪ The questionnaire fully clear and applicable, and can be distributed to the proposed respondents.<br>▪ Only the questionnaire pages should be numbered before distribution. |
| Participant 11 | MSc student in project managemen t" 7 years of experience" | University | ▪ The questionnaire fully clear and applicable, and can be distributed to the proposed respondents. |
| Participant 12 | Professor of Statistics " 28 years of experience" | University | ▪ The questionnaire fully clear and applicable, and can be distributed to the proposed respondents.<br>▪ Only heading of each questionnaire section should be bold. |

## ➢ Questionnaire validity

validity refers to the soundness of the research design being used (Marczyk et al., 2005). Generally, it concerns the degree to which a question measures what it was intended to measure and not something else (Siniscalco, and Auriat, 2005; Brinkman, 2009). By testing the questionnaire validity, we can indicate whether the research is believable and true as high validity typically producing more accurate and meaningful results (Zohrabi, 2013). There are several types of validity (Tayie, 2005; Siniscalco, and Auriat, 2005; Marczyk et al., 2005; Brinkman, 2009; Sekaran and Bougie, 2010). Generally, there are three popular methods to evaluate the validity of the questionnaire, these are:

1. Content validity;
2. Criterion-related validity;
3. Construct validity.

### 1. Content validity

Content validity refers to the assessment of validity based on whether the measure of the concept covers the concept's full meaning (De Vaus, 2002). In this type of validity, researchers can evaluate if different elements, skills and behaviors are adequately and effectively measured (Zohrabi, 2013). There is no numerical way to express content validity and its evaluation is primarily judgmental and intuitive which can be determined by using a panel of persons who shall judge how well the measuring instrument meets the standards of questionnaire construction (Brancato et al., 2006; Brinkman.2009). To this end, the research instruments and the data might be reviewed by the experts in the field of research. Based on the reviewers' comments the unclear and obscure questions can be revised and the complex items reworded. Also, the ineffective and nonfunctioning questions can be discarded altogether (Chung, 2004; Siniscalco, and Auriat, 2005; Zohrabi, 2013). In this research, the content validity of the proposed questionnaire was satisfied, since the development of the scale of measurement items was mainly based on an extensive review of the literature and detailed evaluations by several industry experts, professionals and academics.

### 2. Criterion-related validity

Criterion related validity of the questionnaire is the first statistical test that used to test the validity of the questionnaire. Zikmund et al. (2009) stated that, criterion validity refers to "the ability of a measure to correlate with other standard measures of similar constructs or established criteria". Generally, This type of validity concerns the relationship between scale scores and some specified, measurable criterion (Pallant, 2005). There are a number of ways that criterion validity could be determined and correlational analysis is the basic method to measure he criterion validity of a questionnaire (Sekaran and Bougie, 2010). By measuring the correlations between each of the items to be evaluated and other items in questionnaire the criterion validity of survey can be assessed (Yan et al., 2012). In the same line, Kothari (2004) proposed that criterion validity can be expressed as the coefficient of correlation between test scores and some measure of future performance or between test scores and scores on another measure of known validity. Hence, the criterion validity of the questionnaire used in this study was assessed by measuring the correlation coefficients between each paragraph in one field and the whole field using the proposed sample size which consisted of 20 questionnaires from the collected questionnaires.

Pearson correlation coefficient and p-value are used to test correlations (Elliott and Woodward, 2007). If significance level (p-value) for a paragraph is found to be between [0.01–0.05], this means that the correlation coefficient (α) is significant at $\alpha = 0.05$ and the paragraph is consistent and valid to measure what it was set for. On the other hand, if p-value is less than or equals 0.01, this means that the correlation coefficient is significant at $\alpha = 0.01$ and the paragraph is valid to measure its target. Tables (F.1) to (F.5), listed in Appendix (F) shows the correlation coefficients and p-values for each category items. As shown in these tables the p- values are less than 0.05 or 0.01, the correlation coefficients of each item under any category are significant at $\alpha = 0.01$ or $\alpha = 0.05$, so it can be said that the items under each field are consistent and valid to be measure what it was proposed for.

### 3. Construct validity

Construct validity measures the extent to which the items in a scale all measure the same construct (De Vaus, 2002). It measures the correlation coefficient between one group of variables and all other variables groups of the questionnaire that have the same level of likert scale. Table (3.8) below shows the results of the correlation test, where the correlation coefficient for all categories in the questionnaire are less than 0.05 or 0.01, so the categories are valid and can measure what they are proposed to measure. Clearly, the employment of multiple sources of data collecting helped to improve the construct validity.

In addition, the construct validity can be evaluated by the use of factor analysis as it is a statistical technique used to determine the constructs or domains within the developing measure (De Vaus, 2002; Rattray and Jones, 2007; Sekaran and Bougie, 2010). Factor analysis reflects criterion validity as it addresses the problem of analyzing the interrelationships between a large number of variables to reduce the data of multiple items and then explaining these variables in terms of their common underlying factors (De Vaus, 2002; Brinkman.2009). Factor analysis on different parts of this study questionnaire was conducted and its construct validity was satisfied as can be seen later in the discussion of factor analysis.

### ➢ Questionnaire reliability

Reliability refers to the internal consistency of a measure of a concept (Bryman, 2008; Brinkman.2009). More specifically, it is concerned with the consistency or stability of the score obtained from a measure or assessment over time and across settings or conditions (Marczyk et al., 2005). There are several approaches that can be used to assess the reliability of a questionnaire, such as the test re-test method, internal consistency, and alternate form (Saunders et al., 2009). The test re-test method can be done by repeating the questionnaire to the same sample of the target group in two different time and comparing the scores that obtained in the first time and in the second time by computing a reliability coefficient (Rattray and Jones, 2007; Zikmund et al., 2009). For the most purposes, it can be considered satisfactory if the reliability coefficient is above (0.7). A period from two weeks to a month is recommended for distributing the questionnaires for the second time (De Vaus, 2002; Brinkman, 2009; Field, 2009). Another approach to examine the reliability is to look for consistency within a single measurement.

Table (3.8): Construct validity of the questionnaire

| Field description | Pearson correlation coefficient | p-value |
|---|---|---|
| Local contractors level of awareness/knowledge of energy management. | 0.76 | 0.00* |
| Local contractors degree of practice of energy saving and management in the construction projects. | 0.82 | 0.00* |
| The major drivers enhancing local contractors to adopt energy management during project construction. | 0.77 | 0.00* |
| The key barriers to the implementation of energy management in the contracting companies of Gaza Strip. | 0.64 | 0.00* |
| The best energy management activities to save energy during project construction. | 0.65 | 0.00* |

In this research, due to the complicated conditions, it was too difficult to ask the same sample to respond to the same questionnaire twice within short period. Thus, to overcome the distribution of the questionnaire twice to measure the reliability, statistical methods were used as suggested by statisticians to check the reliability of the questionnaire, two methods often mentioned in this context, are the split-half method and Cronbach's alpha (Brinkman, 2009).

**a) Half Split method**

The simplest method to test the internal consistency of a questionnaire is by dividing the scores a participant received on a questionnaire in two sets with an equal amount of scores and calculating the correlation between these two sets (Field, 2009). The split-half method splits the questions of a dimension in two, for example odd-numbered questions versus even-numbered questions, or just randomly split. Next, it correlates the scores across the two groups (Brinkman, 2009; Zikmund et al., 2009).

In this study, the researcher has calculated the Pearson correlation coefficient between the means of odd rank questions and even rank questions of each field of the questionnaire. Chung (2004) argued that, this score can be biased, especially in small sample sizes, as the item itself is included in the total score. Therefore, to reduce this bias, a corrected item-total correlation should be calculated. Then, correcting the Pearson correlation coefficients can be done by using Spearman Brown correlation coefficient of correction. Consistency " test reliability" coefficient is between 0.0 and + 1.0, and a frequently referenced acceptable standard for test reliability is 0.70 (Chung, 2004; Pallant, 2005). As reported in Table (3.9) below, all the corrected correlation coefficients values are between 0.80 and 0.93 and the general reliability for all items equals 0.78. Because corrected correlation coefficients values easily exceed the 0.70 standard, we can safely assume that our test instrument is reliable

(Chung, 2004). In addition, the significance values are less than 0.05, which indicates that the corrected correlation coefficients are significant at α = 0.05. Thus, it can be said that the studied fields were reliable according to the Half Split method.

Table (3.9): Reliability test by Half-Split coefficient method

| Field description | Pearson correlation coefficient | Spearman-Brown Coefficient | Sig. (2-tailed) |
|---|---|---|---|
| Local contractors level of awareness/knowledge of energy management. | 0.81 | 0.90 | 0.00* |
| Local contractors degree of practice of energy saving and management in the construction projects. | 0.88 | 0.93 | 0.00* |
| The major drivers enhancing local contractors to adopt energy management during project construction. | 0.83 | 0.91 | 0.00* |
| The key barriers to the implementation of energy management in the contracting companies of Gaza Strip. | 0.72 | 0.84 | 0.00* |
| The best energy management activities to save energy during project construction. | 0.67 | 0.80 | 0.00* |

**b) Cronbach's Alpha coefficient**

Coefficient alpha (α) (also known as "Cronbach's alpha") is the most commonly applied reliability coefficient and it demonstrates whether or not the different items converge (Zikmund et al., 2009). It is also called an internal-consistency coefficient because it provides an estimate of reliability based on the covariation among items internal to the test (Webb et al., 2006). Coefficient alpha ranges in value from 0, meaning no consistency, to 1, meaning complete consistency (all items yield corresponding values (Bryman, 2008; Zikmund et al., 2009). As a rule of thumb, Pallant (2010) advised that an Alpha level of 0.7 met the necessary requirements. Furthermore, Brinkman (2009) highlighted that Alpha levels as low as 0.6 are acceptable for new scales. Internal consistency tests based on Cronbach's Alpha were conducted on the Likers scale questions in the questionnaires. For the current sample, Table (3.10) indicated that Alpha coefficients were determined to be between 0.79 to 0.92. Hence, these values for Cronbach's alpha indicating that the data collected from the survey was interrelated and that the scale was consistent with the sample

Table (3.10) : Reliability test by Cronbach's Alpha coefficient method

| Field description | Cronbach's lpha ($C\alpha$) |
|---|---|
| Local contractors level of awareness/knowledge of energy management. | 0.86 |
| Local contractors degree of practice of energy saving and management in the construction projects. | 0.92 |
| The major drivers enhancing local contractors to adopt energy management during project construction. | 0.79 |
| The key barriers to the implementation of energy management in the contracting companies of Gaza Strip. | 0.81 |
| The best energy management activities to save energy during project construction. | 0.82 |

### 3) Final questionnaire design

The results from the pilot study tests were used to validate the distributed research questionnaire. Overall, the validity and reliability of the semi-final questionnaire that has been prepared after pre-field and field pretesting and distributed to the targeted sample "contracting organizations" have been satisfied. Then, it can be considered as the final version of questionnaire and became ready to be for further analysis and discussion. Its questions were being formulated in a way that introduces the concept to the participants simply and smoothly in order to gain the needed responses to answer the main research questions and to achieve the research objective. Elliott and Woodward (2007) asserted that, variables labels are important because they can help in more clearly understand and interpret statistical output. Accordingly, the questionnaire variables\statements in each field of this study was labeled by shortcut label in a systemic way that can make the analysis presentation and discussion easier. Tables presented below Table (3.12) to Table (3.16) provide a clear description of all variables included in studied questionnaire and there label. It is worth noting that the number assigned to each label didn't related in any way to their order of importance or strength but simply serves the purpose of identification.

To ensure that respondents accurately able to answer the questions and receive the same stimuli, the questionnaire included clear definitions of the terms that related to energy management. In addition, the majority of employees in the Palestinian construction industry come from different backgrounds and education levels with a minority able to speak English as a second language and able to understand the questions. Therefore, a decision was made to translate the questionnaire into Arabic to make it clear and easy to understand for the respondents to provide more reliable findings. An English version of the final questionnaire was prepared to help in documenting this research as described in Appendix (A), and it was developed in Arabic to be more understandable by respondents and shown in Appendix (B).

The final questionnaire of this study was divided into six main parts as summarized in Table (3.11) below, which included the following parts:

- **First part: Respondent and company general information**

The first part of the questionnaire consisted of 8 questions proposed to collect industry information and general respondents' demography information. In this part, the respondents were asked to indicate their highest level of education, working experience in there company and in the industry, the type and background of the company in which they were working, and the nature of the project, and so on. Comparing the demographics of the sample with the demographics of the target population is one means of inspecting for possible biases in response patterns (Zikmund et al. 2009). Tayie (2005) reported that, some questionnaires respondents may still refuse to answer personal items and hence, the anonymity of this study respondents has been preserved because no company or personal information were collected.

- **Second part: Local contractors level of awareness/knowledge of energy management**

In second part, the awareness of the respondents on the energy management measures were investigated to satisfy the first objective of this study. This part was designed to capture the respondents' perception on the degree of agreement about 10 energy management awareness features. These features involved a statements about some energy and sustainability issues and definitions by which the respondent’s energy knowledge investigated.

- **Third part: Local contractors degree of practice of energy saving and management in the construction projects**

This part regarding the respondent’s energy management and conservation application level which was required by the second objective of this study. This section consisted of 17 questions which revealed the respondents’ energy conservation behavior. Respondents were requested to evaluate their company's adoption of energy management requirements in the construction project.

- **Fourth part: The major drivers enhancing local contractors to adopt energy management during project construction**

To realize the third objective of this study, the fourth part of questionnaire was designed to evaluate the effectiveness of each of the listed 26 drivers in enhancing the respondent’s company to adapt energy management and saving during project construction.

- **Fifth part: The key barriers to the implementation of energy management in the contracting companies of Gaza Strip**

The fifth part consisted of 31 barriers that inhibiting the local construction contractors from adapting energy management practices in its activities. By investigating and analyzing these barriers set, the fourth objective of this study can be completed.

- **Sixth part: The best energy management activities to save energy during project construction**

The fifth part aimed to acquire the last objective of this study and it was consisted of 33 energy management and saving practices that are collected from previous studies and discussions. In this part of the survey the respondent was asked to rate each practice according its effectiveness in saving energy during onsite construction

Table (3.11): Components of the Study questionnaire

| Part No. | Part title | No. of questions | Measurement scale |
|---|---|---|---|
| 1 | Respondent and company general information | 8 | Nominal |
| 2 | Local contractors level of awareness/knowledge of energy management. | 10 | Ordinal (Likert scale) |
| 3 | Local contractors degree of practice of energy saving and management in the construction projects. | 17 | Ordinal (Likert scale) |
| 4 | The major drivers enhancing local contractors to adopt energy management during project construction. | 26 | Ordinal (Likert scale) |
| 5 | The key barriers to the implementation of energy management in the contracting companies of Gaza Strip. | 31 | Ordinal (Likert scale) |
| 6 | The best energy management activities to save energy during project construction. | 33 | Ordinal (Likert scale) |

### 3.4.3 Third Phase: Main data collection

This section explains the process of data collection, particularly the questionnaires administered, the collected data received, and the procedures used for data analysis.

**Questionnaire distribution**

The final version of the questionnaires were personally distributed to 100 contracting companies in Gaza Strip according to the numbers and distribution proposed by stratified random sampling method as mentioned earlier. Several factors should be considered in the selection of the appropriate questionnaire distribution method. Among them the objective of the study, the target group and its geographical distribution, the type of the questions and the available resources (Synodinos, 2003)**.** The size of the questionnaire was large (11 pages and more than 100 questions) and in orders to illicit the contractors' interest and get their commitment, the researcher has delivered the questionnaire in person to the contractor's offices and explained them the objective and importance of the research to the contractors and the construction industry in general. The respondents were asked to select the appropriate answer for each statement/variable included in questionnaire by ticking the this answer. This method was undertaken on both the pretest and main study. Zohrabi (2013) argued that self-administration method can satisfy high rate of return where possible. In addition, this method benefits from the absence of an interviewer from the process which help in removing a major source of potential bias in the responses and makes it easier for a respondent to be honest about sensitive subjects (Lee, 2006). In general, this method is cheap and easy to administer the questionnaire and can be completed at respondent's convenience and administered in a standard manner (Synodinos, 2003).

A covering letter explained the purpose and the potential benefits of the research was attached to each questionnaire. It was also assured that all the information provided by respondents will be kept confidential and will not be used for any purposes unrelated to the dissertation. Further, the contractors were promised to be given the research report and a specific report that assess maturity of their organization relative to other participant organizations.

**Questionnaire collection and response rate**

Of the 100 questionnaires dispatched to the selected sample, 86 were returned. After several revisions, 10 out of the 86 were found incomplete because respondents had submitted the questionnaire without responding on all questions or duplicated the answers for the same question.

The total response rate, as shown in the equation below, was 76%. According to Saunders et al. (2003), this response rate can be considered high and adequate to carry out the data analysis. Additionally, when compared with similar studies (e.g. De Groot et al., 2001; Rohdin et al., 2007; Thollander and Ottosson, 2010), the response rate of 76% can be considered acceptable and high.

$$\text{Total response rate (\%)} = \frac{\text{Total number of valid responses} \times 100}{\text{Total number of sample}}$$

Table (3.12): Energy management features to measure participants awareness

| Item label. | Energy management awareness feature |
|---|---|
| AEM1 | Onsite energy costs represent an important part of the project overall costs |
| AEM2 | Increased onsite energy use may result in different negative environmental impacts |
| AEM3 | GHG emissions are the highest negative environmental impact associated with energy use during onsite construction |
| AEM4 | There is gap between knowledge and application of energy efficiency in local construction industry |
| AEM5 | Energy management is one component of the sustainability concept |
| AEM6 | Energy management improves the company performance (competitive advantage) |
| AEM7 | Application of energy management affects the project management method/style |
| AEM8 | Energy management is one of the construction business ethics |
| AEM9 | Energy management highly reduces overall project cost |
| AEM10 | Energy management highly reduces the negative environmental impacts of the project. |

Table (3.13): Energy management requirements to measure practice level of energy management

| Item label. | Energy management application requirement |
|---|---|
| PEM1 | My company preparing an environmental management program for each project |
| PEM2 | My company presenting energy management as one component of its written policy |
| PEM3 | My company providing a strategy to save energy for each project |
| PEM4 | My company preparing an energy management plan for each project to save energy during project construction |
| PEM5 | My company establishing an energy saving objectives and targets for all construction works |
| PEM6 | My company identifying unique key performance indicators related to energy issues during project construction |
| PEM7 | My company conducting energy audit and accounting for its construction works to record and report energy consumption and saving opportunities |
| PEM8 | My company setting a monitoring system for energy use during onsite works |
| PEM9 | My company conducting periodic revision of significant historical data related to energy aspects for construction works |
| PEM10 | My company conducting regular assessment of its future energy needs |
| PEM11 | My company regularly assessing the compliance and committing to all legal obligations and other regulatory requirements related to energy aspects for construction industry |

Table (3.13): Energy management requirements to measure practice level of energy management "Continued"

| Item label. | Energy management application requirement |
|---|---|
| PEM12 | My company hiring a specialized committee or person responsible for all energy issues during construction works |
| PEM13 | My company providing the required experienced personnel, as well as technical and financial resources to save energy during construction works |
| PEM14 | My company introducing incentives for the employees to efficient energy use during construction works |
| PEM15 | ' company creating and using energy use manual to save energy during construction works. |
| PEM16 | My company providing specialized energy management training programs for its employees. |
| PEM17 | My company providing onsite awareness programs and tools to efficient energy use during construction works |

Table (3.14): Key drivers to adopt energy management in construction companies

| Item label. | Driver to adopt energy management |
|---|---|
| DEM1 | Existence of government regulations related to energy consumption and saving issues for construction industry. |
| DEM2 | Strength and enforcement of the governmental requirements for onsite construction energy saving. |
| DEM3 | Contractor energy performance is one criteria of the company rating in local construction sector . |
| DEM4 | Imposed governmental tax for energy use and emissions on construction companies. |
| DEM5 | Contract conditions containing specific environmental requirements |
| DEM6 | Increased education level of the contractor employees. |
| DEM7 | Construction employees awareness of onsite energy use and problems. |
| DEM8 | Existence of sustainability policy within the contractor organization. |
| DEM9 | Availability of experts for energy efficiency in construction industry |
| DEM10 | Adoption of energy performance contracts (EPC) in local construction market. |
| DEM11 | Availability of long term energy management strategies within the construction companies. |
| DEM12 | Top management support to sustainable, energy management and saving activities. |
| DEM13 | Contractor willingness to satisfy client/donor requirements regarding energy issues. |
| DEM14 | Availability and frequency of internal training on energy management |
| DEM15 | Availability of information on successfully implemented energy management practices in construction. |
| DEM16 | Government support for researchers in energy management in construction industry. |

Table (3.14): Key drivers to adopt energy management in construction companies "Continued"

| Item label. | Driver to adopt energy management |
|---|---|
| DEM17 | Availability of different energy types, sources and alternatives in local market. |
| DEM18 | Rising energy prices in local market. |
| DEM19 | Cost saving gained from adopted energy management strategies. |
| DEM20 | High energy amounts and costs required during onsite works in the project. |
| DEM21 | Decrease price levels of energy saving technology for construction industry. |
| DEM22 | Availability of the financial support for energy saving strategies/plans and investments. |
| DEM23 | Improvement of the company competitive advantage and reputation as a result of adopting energy management in its projects. |
| DEM24 | Improved onsite working conditions. |
| DEM25 | Availability of building code requirements for energy saving and management. |
| DEM26 | Availability of new energy saving solutions, products and tools in local market. |

Table (3.15): The key barriers to the implementation of energy management in contracting companies

| Item label. | Barriers to the implementation of energy management |
|---|---|
| BEM1 | Lack of governmental legislations for environment protection and energy conservation in construction sector. |
| BEM2 | No specific person or committee assigned to deal with onsite energy issues. |
| BEM3 | Lack of government support/ incentives for energy management in construction industry. |
| BEM4 | Lack of energy management codes and regulation in construction. |
| BEM5 | Lack of audit and quantitative evaluation tools for the energy performance of the construction companies . |
| BEM6 | High competition between the local contracting companies working in the construction sector. |
| BEM7 | Fragmentation of the construction process (Increased industry parties and divided processes). |
| BEM8 | Difficulties to access technical information and expertise related to energy management in construction. |
| BEM9 | The contract documents do not impose any special conditions/specifications for onsite energy management. |
| BEM10 | Company senior management doesn't provide support for energy saving activities |
| BEM11 | Company management lack interest in onsite energy costs and consumption issues. |
| BEM12 | Additional costs needed to improve the company energy efficiency |
| BEM13 | The company lacks long-term vision and it is short-term oriented. |

Table (3.15): The key barriers to the implementation of energy management in contracting companies "Continued"

| Item label. | Barriers to the implementation of energy management |
|---|---|
| BEM14 | The company lacks of procedures or strategies to promote sustainable construction |
| BEM15 | Poor enforcement of the governmental legislations related to energy issues in construction industry. |
| BEM16 | The company lacks of ethical standards and corporate social responsibility. |
| BEM17 | Tight project duration makes the management concerned about the time required to adopt energy management practices. |
| BEM18 | Lack of the company staff awareness on the importance of energy management during onsite construction. |
| BEM19 | Lack of the client/donor awareness of the importance of energy management during onsite construction. |
| BEM20 | Resistance to change from traditional practices to more energy efficient practices. |
| BEM21 | Management believe that there is no/little scope for the company energy performance improvement . |
| BEM22 | Conflicts of interest within the project members (owner/consultant/contractor). |
| BEM23 | Lack of technical skills\knowledge on construction energy management technologies. |
| BEM24 | Lack of training and education in energy management, sustainable design and construction. |
| BEM25 | Lack of demonstration examples on energy management in construction industry |
| BEM26 | High costs of energy management options (measures/technologies). |
| BEM27 | Construction energy costs are not sufficiently important compared with other costs. |
| BEM28 | Lack of budget funding to adopt energy management practices and technologies. |
| BEM29 | Low profit margins gained from adopting energy management practices. |
| BEM30 | Lack of innovative energy technologies/equipment in local market. |
| BEM31 | Uncertain local economic environment. |

Table (3.16): Best activities to save energy use during project construction

| Item label. | Energy management activities |
|---|---|
| SEM1 | Applying the governmental regulations requirements related to construction energy use. |
| SEM2 | Adopting of the governmental fiscal measures related to onsite construction energy issues. |
| SEM3 | Adopting of the available energy code requirements for construction industry. |
| SEM4 | Motivate the company employees to apply more onsite energy saving practices. |
| SEM5 | adoption of more energy efficient construction methods as opposed to traditional construction methods during construction phase. |
| SEM6 | Participating in environmental friendly projects as possible. |
| SEM7 | Selecting subcontractors who are experienced in energy issues and management in construction . |
| SEM8 | Setting a quantitative targets for onsite energy use and saving in each activity of the project. |
| SEM9 | Developing scientific, reasonable energy action plan for the project to make full use of onsite energy and resources. |
| SEM10 | Development of adequate energy database for the company projects. |
| SEM11 | Conducting energy audits on the construction site to identify energy use and energy saving opportunities. |
| SEM12 | Systematic review and analysis for the energy consumption of onsite activities and equipment. |
| SEM13 | Use of a monitoring system for energy use during onsite works. |
| SEM14 | Closer onsite supervision and quality control on energy issues. |
| SEM15 | Collect information on available energy saving systems, technologies and policies in local construction sector. |
| SEM16 | Establishing good onsite communications between project staff about energy matters during construction phase. |
| SEM17 | Employing a specialized team or person responsible for all energy issues during onsite works. |
| SEM18 | Detailed reporting of the company onsite energy activities. |
| SEM19 | Using onsite energy manual (detailed work instructions) to save energy during onsite construction. |
| SEM20 | Conducting periodic meetings and training programs for the contractors staff in energy conservation systems/technologies. |
| SEM21 | Identification and revision of the performance standards for the equipment used onsite |
| SEM22 | Frequent examination of the energy efficiency of all equipment used on construction site. |
| SEM23 | Reducing the unnecessary use of energy consuming equipment and machines used during onsite construction. |
| SEM24 | Replacement of high energy consuming equipment with lower energy consuming equipment. |

Table (3.16): Best activities to save energy use during project construction "Continued"

| Item label. | Energy management activities |
|---|---|
| SEM25 | Replacement of onsite mechanical equipment with the use of manual labor where applicable. |
| SEM26 | Practicing of onsite construction methods leading to lower material use . |
| SEM27 | Selecting where possible only local sources of materials supply. |
| SEM28 | Increasing the use of recycled building materials. |
| SEM29 | Reducing excessive material and wastage during onsite construction. |
| SEM30 | Using available energy saving technologies and solutions during onsite construction. |
| SEM31 | Utilization of renewable energies and green technologies for onsite production, transport and performance. |
| SEM32 | Software development for onsite energy monitoring and evaluation. |
| SEM33 | Optimization of the transportation of raw materials and equipment to and within the site. |

**Data analysis**

Once the questionnaires collected, it should be processed and analyzed in accordance with the outline laid down for the purpose at the time of developing the research plan. The data should be presented in a well-structured and easy way (Biggam, 2008). Kothari (2004) defined data analysis as " the computation of certain measures along with searching for patterns of relationship that exist among data-groups". The overall goal of data analysis is to arrive at a general understanding of the phenomenon under study (Tayie, 2005). Quantitative data are data on which computations such as addition and subtraction make sense (Elliott and Woodward, 2007). Hence, the data collected in this final stage was quantitative in nature and thus could be analysed using statistical methods. The computerised tool SPPS (Statistical Program for Social Sciences version.22) was used as the data analysis tool to help tabulate data and establish relationships between variables.

However, before analysis began gathered data was cleaned prior to conducting the data analysis. In this process several actions were undertaken to locate outliers, missing data, errors and any inaccuracy of the data. Additionally, several preliminary processes were conducted such as editing data, handling blank responses, coding data, categorizing data, creating data files and some statistical calculations. The aim of these processes was to ensure a consistency of data, and to allow results to be meaningfully interpreted. Kothari (2004) categorised data analysis into descriptive analysis and inferential analysis. The choice of statistics is determined by many previous decisions such as the method of analysis, level of measurement of the variables and complexity of the research question (DE Vaus, 2002). In the same line, valid questionnaire data were subjected to several statistical analyses procedures starting with basic descriptive statistics to the more complex procedures like factor analysis and inferential analysis.

### A. Descriptive statistics analysis

Descriptive analysis is the elementary transformation of data in a way that describes the basic characteristics such as central tendency, distribution, and variability (Preston, 2012). Traditionally, this type of analysis concerned with numerical description of a particular group observed and any similarity to those outside the group cannot be taken for granted (Singh, 2006). Descriptive statistics is the simplest method of analysis that can summarize responses from large numbers of respondents in a few simple statistics in which, the general overview of the results can be provided either in percentages, or actual numbers and (Naoum, 2007). When a sample is obtained, the sample descriptive statistics are used to make inferences about characteristics of the entire population of interest (Preston, 2012).

In this study, descriptive statistics are used to describe the main features of the collected data in quantitative terms. The descriptive statistics encompassed frequency distributions, measures of central tendency (the mean and average score), Relative Importance Index (RII) and measures of dispersion such as the standard deviation. These techniques were employed for analyzing data related to the characteristics of the respondents and their organizations. They were also used for the initial analysis of rating score data of the various research variables. In addition, the purpose of these statistical analyses is to evaluate the accuracy of the data. The following parts provide detailed description about main features of descriptive analysis conducted in this study.

#### ❖ Average index method

The second and third questionnaire parts aimed to measure the level of energy management and practice in local contracting companies, respectively. Respondents of the survey were asked to indicate their degree of agreement about the listed energy management features using a scale of 1 (strongly disagree) to 5 (strongly agree). Forth more, to measure the practice degree of energy management, the respondents were asked to assess the extent to which they had adopted various energy management requirements using a scale of 1 (never applied ) to 5 (always applied).

The data collected from the questionnaire survey for the second and third parts of this study questionnaire which were related to the first and second objectives have been summarized by using mean score, and their corresponding rankings. The mean scores are more specific known as average index was and used to measure the awareness and application levels of energy management and ranking the awareness features and application requirements from the most known and practiced to the least, respectively. The mean is also easier to be determined and interpreted and can be employed in various other calculations. Implying the mean is a reasonable and valid measure based on the type of the data scales used in this study. The same method was used and discussed by Memon et al. (2006), Bassioni et al. (2010), Memon and Zin (2010), Wai et al. (2011), Lian et al. (2012), Mohamad et al. (2012), Choong et al. (2012), Trianni et al. (2013), Cagno and Trianni (2013), Venmans (2014), Memon et al. (2014) and Abdulkadir et al. (2014) to establish average index for the different factors. Abd.Majid (1997) called mean score (MS) as average index which was computed for each factor by the following formula which is very popular with researchers in the construction management field (Wai et al., 2011; Memon et al., 2014):

$$\text{Average Index} = \left[\frac{\sum_{i=1}^{5} a_i x_i}{\sum_{i=1}^{5} x_i}\right]$$

Where,

$a_i$= Constant expressing the weight given to i ,

$x_i$= Variable expressing the frequency of the response for, i = 1,2,3,4,5 and illustrated as follows:

$X_1$= Frequency of the response corresponding to $a_1$= 1;

$X_2$ = Frequency of the response corresponding to $a_2$= 2;

$X_3$= Frequency of the response corresponding to $a_3$= 3;

$X_4$= Frequency of the response corresponding to $a_4$= 4;

$X_5$= Frequency of the response corresponding to $a_5$= 5.

Mohamad et al. (2012) and Lian et al. (2012) used a discrete scale (Likert scale) converted to a continuous index (average index) which then can be split into discrete categories. The MS could be further interpreted based on each respondent's rating. To achieve this, MS can be split into discrete categories as described in Table (3.17) to assess awareness level and degree of practice of energy management

Table (3.17): Average Index ranges and indicators description, adopted from Mohamad et al. (2012) and Lian et al. (2012)

| Average index indicator | Average Index range (MS) | Description |
|---|---|---|
| Very high | 4.50 ≤ MS ≤ 5.00 | The respondent has very high energy management related knowledge or application level if the answered statement have average index (MS) value above 4.5 |
| High | 3.50 ≤ MS < 4.50 | The respondent has high energy management related knowledge or application level if the answered statement have average index (MS) value between 3.5 and 4.5 |
| Average | 2.50 ≤ MS < 3.50 | The respondent has average energy management related knowledge or application level if the answered statement have average index (MS) value between 2.51 and 3.5 |
| Low | 1.50 ≤ MS < 2.50 | The respondent has low energy management related knowledge or application level if the answered statement have average index (MS) value between 1.51 and 2.5 |
| Very low | 0.00 ≤ MS < 1.50 | The respondent has very low energy management related knowledge or application level if the answered statement have average index(MS) value between 0.00 and 1.50 |

### ❖ Relative Importance Index (RII)

In this study, each variable/statement was ranked on the basis it's Relative Importance Index (RII) value. In general, Relative Importance index can be considered as one types of ranking (rank order) scaling because the researcher measured respondents' preferences by comparing the involved variables/statements under each section on the basis of their RII values, then the variables\statements have been arranged in some form of order (Kothari, 2004; Sekaran and Bougie, 2010). For that, to achieve the last three objectives of this study, the Relative Importance Index (RII) was used to rank the importance of each variable\statement based on numerical scores from the questionnaire responses. The RII was calculated to rank energy management adoption drivers, barriers and the best activities to save energy during project construction.

In general, RII value ranges from 0 to 1; a higher RII indicates that a particular factor is more significant than those with relatively lower RIIs. The RII for groups was determined by averaging the RIIs of all individual factors within the same group. Moreover, relative importance index technique has been used in many domains to evaluate the comparative importance of a single item to others. Several studies used it for measuring attitudes with respect to surveyed variables such as, Majdalani et al. (2006); Wong and Vimonsatit (2012); Enshassi et al. (2013); Djokoto et al. (2014); Vidhate and Patil (2015).

The five-point scale ranging from 1 to 5 was adopted in this study and hence, transformed to relative importance indices (RII) for each statement/variable as follows:

$$RII = \frac{\sum_{i=1}^{n} Wi}{\mathrm{A} \times \mathrm{N}}$$

Where,

RII = Relative Importance Index;
Wi = Weight of the criteria (i) given by respondents ranged between 1 and 5;
A = The maximum weight given by respondents;
N = The number of respondents.

### ❖ Standard deviation (SD)

Mean of a variable is simply an average score, and a standard deviation is a measure of variability indicating the average amount that scores vary from the mean (Marczyk et al., 2005). Standard deviation can be defined as "the positive square root of the variance which is commonly used in explaining how widely the values in a data set are spread or are clustered together around the mean" (Wai et al. 2011). Elliott and Woodward (2007) argued that, standard deviation (SD) should be used to describe the variability of the data when the researcher reporting descriptive statistics. In addition, SD provides a way for researchers to compare between variables that have the same average score value (Marczyk et al., 2005). When its value is low, the mean can be considered as more satisfactory measure for ranking. Forth more, by examining standard deviations, any variable ranking or relative standing can be judged (De Vaus, 2002). The fact that the standard deviations are all less than 1.0 for 5-

points Likert scale indicates that there is little variability in the data and consistency in agreement among the respondents (Field, 2009). In general, SD values have been calculated in this study to assess the data variability and in ranking the variables/statements that had the same mean (average score) value.

### ❖ Factor analysis

Factor analysis is a powerful and often-used technique in construction management research (Lingard and Rowlinson, 2006). Factor analysis is a statistical technique for examining the underlying structure or the structure of interrelationships among a large number of variables (Hair et al., 2010). This analysis yields a set of factors or underlying dimensions which when interpreted and understood, describe the data in a more meaningful number of concepts than the original individual variables (Field, 2009). Factor analysis has many uses, Williams et al. (2010) briefly described three of which here:

- **Firstly,** factor analysis reduces a large number of variables into a smaller set of variables (also referred to as factors).
- **Secondly,** it establishes underlying dimensions between measured variables and latent constructs, thereby allowing the formation and refinement of theory.
- **Thirdly,** it provides construct validity evidence of self-reporting scales.

Factor analysis is a general name denoting a class of procedures primarily used for data reduction and summarization ( Malhotra and Birks, 2006). Generally, factor analysis consists of five parts as described later in detail, which are:

- ✓ **First phase,** a preliminary analysis will be conducted to test the suitability of the data and the sample for a factor analysis.
- ✓ **Second phase,** factors will be extracted and presented.
- ✓ **Third phase,** factors will be rotated in order to see if any variables should not be included in the intended constructs.
- ✓ **Fourth phase,** the reliability of the chosen constructs will be tested through the Cronbach's alpha test.
- ✓ **Fifth phase,** in the end, factors should be interpreted and labeled.

It worth noting that, the terms of factor analysis and Principal Component Analysis (PCA) are often used synonymously in seveal previous researches (Rattray and Jones, 2007). The type of factor analysis in this study was Exploratory Factor Analysis (EFA) because the researcher was uncertain about how many factors may exist among a set of variables( Zikmund et al., 2009).

### First phase : Preliminary analysis of the suitability of the study data and sample for factor analysis.

One of the most common questions and the most important criteria that arises in applications of factor analysis before proceeding in the analysis process are related to the type of the study data and the minimum sample size required for the analysis. In particular, the suitability of the data set for this type of analysis can be established by following a range of pre-analysis checks and the main two principles are described below :

**1. Type of the study data (variables)**

Only variables that are subject to a perceptive opinion of the respondents should be chosen to be included in the factor analysis. A variable is anything that changes its value and a factor is a linear combination of variables (Mane and Nagesha, 2014). Otherwise, a factor is an underlying dimension that account for several observed variables (Kothari, 2004). By only including variables prone to subjective opinions, it would be possible inspect if one can create constructs out of multiple, subjectively measured items from the questionnaire (Rehbinder, 2011). In addition, the variables to be included in factor analysis should have roughly normal distributions. The assumption of normality is important to generalize the results of analysis results beyond the sample collected (Field, 2009). Yong and Pearce (2013) pointed out that, factor analysis is usually performed on ordinal or continuous variables, although it can also be performed on categorical and dichotomous variables.

Consequently, subjective variables with ordinal scale like opinions of the respondents towards the energy management drivers, barriers and activities to save energy were included in the factor analysis. In addition these variables had a normal distribution as argued by the Central Limit Theorem, discussed later in this study. On other hand, objective variables like respondent's education level, experience, firm classification, size and etc., were not included. In addition, the energy management features to measure awareness and requirements to measure degree of practice of energy management hadn't included in factor analysis as its reduction will not benefit the study and its objectives. Besides that, these were a measures used to describe a particular situation and must be fully shown in the study to describe this situation. It is worth noting that, in this study the variables included in factor analysis can be named as item also.

**2. Sample size**

Factor analyses are generally performed with large sample sizes. Larger sample sizes in applications of factor analysis tends to provide results such that sample factor loadings are more precise estimates of population loadings and are also more stable, or less variable, across repeated sampling (Yong and Pearce, 2013). In small samples, the correlation coefficients among the variables are less reliable, tending to vary from sample to sample (Pallant, 2005). Although sample size is important in factor analysis, there are varying opinions, and several guiding rules of thumb were proposed by many researchers. Two common approaches have been proposed as a guidelines for the sample sizes required to apply factor analysis, as follows:

**a. Absolute number of the sample (N)**

Many early recommendations focused on the importance of absolute sample size. There are a wide range of recommendations regarding minimum sample size to obtain adequate and stable factor analysis solution. Tabachnick and Fidell (2007) stated that 'it is comforting to have at least 300 cases for factor analysis'. Comrey and Lee (1992) provided the following scale of sample size adequacy: 50 (very poor) , 100 (poor) , 200 (fair), 300 (good) , 500 (very good) , and 1,000 or more(excellent). Gorsuch (1974) characterized sample sizes above 200 as large and below 50 as small. Cattell (1978) proposed that 500 would be a good sample size, commenting that in the context of most problems, however, 250 or 200 could be acceptable. MacCallum et al. (1999) have shown that the minimum sample size or sample to variable ratio depends on other aspects of the design of the study. In short, their study indicated that as communalities become lower the importance of sample size increases. With all communalities above 0.6, relatively small samples (less than 100) may be perfectly adequate. With communalities in the 0.5 range, samples between 100 and 200 can be good enough provided there are relatively few factors each with only a small number of indicator variables. In the worst scenario of low communalities (well below 0.5) and a larger number of underlying factors they recommend samples above 500. Hair et al. (2010) suggests that factor analysis shouldn't be applied for sample size less than 50 observations and preferred sample size of 100 or larger. de Winter et al. (2009) and Sapnas and Zeller (2002) determined adequate sample sizes for principal component analysis and suggested that a sample size between 50 and 100 was adequate to evaluate psychometric properties of measures of social constructs.

**b. Sample to variable ratio (N/p ratio)**

Another set of recommendations also exist providing researchers with guidance regarding how many participants are required for each variable, often termed, the sample to variable ratio, often denoted as N:p ratio where N refers to the number of participants and p refers to the number of variables. This ratio and range may be from 5:1 to 20:1 (Hair et al., 2010). Kass and Tinsley (1979) recommended having between 5 and 10 participants per variable up to a total of 300 respondents. Others suggested that 5 cases for each item is adequate in most cases as discussed in Tabachnick and Fidell (2007).

Sample to variable ratio for all parts to be factor analyzed in his study have obtained from a sample size of 76 respondents which is considered as small sample size, and with different number of variables in each part of the questionnaire. Table (3.18) described these ratios values, and it can be seen that the sample to variable ratio for all parts to be factor analyzed in this study were less than 5 as recommended by Tabachnick and Fidell (2007) and Hair et al. (2010). For that and in view of the limitation on the sample size, it is necessary to ensure that the sample size in this study would not adversely affect the results of classification as generated by the factor analysis because small samples and low sample to variable ratio can lead to erroneous conclusion (Lingard and Rowlinson, 2006). Low sample to variable ratios gained as a result of a small sample size (76 respondents) and large number of included items (variables), which have been obtained in data collection process of this study and included in the final questionnaire.

Costello and Osborne (2005) stated that, for any sample to variable ratio, a smaller sample size can be used if the research data are strong. Strong data in factor analysis means uniformly high communalities without cross loadings (any variable loaded on two factors by high loading values), plus several variables loading strongly on each factor. Based on the previous conclusion, sample to variable ratio in this study can be neglected in deciding about the suitability of factor analysis process because the researcher has considered only strong data to be included in the final solution of factor analysis. To obtain a strong data in this study, several runs of data filtration has been conducted. In that, any variable that have a communality value less than 0.5 or loaded on the two or more factors with factor loadings more than 0.5 “cross loaded” have been removed from analysis. In addition, variables with high factor loading (equal or more than 0.5) were retained and considered for further factor analysis. Accordingly,  satisfying  the strong data assumption can validate the suitability of the factor analysis for this study. In addition, the sample size of 76 respondents in this study can be considered adequate as it was larger than 50 as proposed by de Winter et al. (2009) and Sapnas and Zeller (2002). In depth discussion have been provided later in this chapter about communality, cross loading and factor loading .

Table (3.18): Study sample and variables characteristics

| No. | Field description | Variables No. (N) | Sample size (P) | (N:P) ratio |
|---|---|---|---|---|
| 1 | Major drivers enhancing local contractors to adopt energy management during construction phase. | 26 | 76 | 2.92 |
| 2 | Best energy management activities to reduce energy use during construction phase. | 33 | 76 | 2.3 |
| 3 | key barriers to the implementation of energy management during construction phase in Gaza Strip | 31 | 76 | 2.45 |

**3. Factorability of the correlation matrix**

The correlation between each pair of the study variables can be arranged in what’s known as an R-matrix. An R-matrix is just a correlation matrix: a table of correlation coefficients between variables (Field, 2009). Correlation matrix is a lower triangle matrix showing the simple correlations, *r*, between all possible pairs of variables included in the analysis (Malhotra and Birks, 2006).

To ensure a good factor analysis, the variables should be correlated to some extent, but not be perfectly correlated (De Vaus, 2002; Malhotra and Birks, 2006; Field, 2009). In general, the presence of correlated variables can justify the validity and appropriateness to apply factor analysis in the study (Hair et al., 2010). Pallant (2005) and Tabachnick and Fidell (2007) recommended inspecting the correlation matrix (often termed Factorability of R) for several correlation coefficients over 0.30.  If no correlations go beyond 0.30, then the researcher should reconsider whether factor analysis is the appropriate statistical method to utilize. Also, the correlation matrix between the variables should be scanned by visual inspection in order to see if there is any correlations coefficient above 0.9 (Field, 2009; Yong and Pearce, 2013). Both the highly and lowly correlating items should be eliminated. For that, any variable should be considered and retained in further factor analysis process if it have a several correlations with the other variables above 0.3 “ not all correlations” and none of these are greater than 0.9. When all correlations of any variable are less than 0.3 or at least one correlation greater than 0.9 have been found, the researcher have to consider eliminating this variable from the analysis. In addition, Hair et al. (2010) reported that, researcher should question the application of factor analysis if all correlations in the correlation matric are equal.

In accordance to this discussion, the correlation matrix for all variables/items included in each part of this study was generated and tested to validate the factorability of the correlation matrix. In this, any variable without any correlation larger than 0.3 or with at least one correlation larger than 0.9 have been considered for elimination and removed for the next stages of factor analysis.

**4. Kaiser-Meyer-Olkin (KMO) Measure of Sampling Adequacy/Bartlett's Test of Sphericity**

Several tests should be used to assess the suitability of the respondent data for factor analysis. These tests include Kaiser-Meyer-Olkin (KMO) Measure of Sampling and Bartlett's Test of Sphericity (Malhotra and Birks, 2006; Williams et al., 2010). Kaiser Meyer Olkin (KMO) statistic compares the magnitude of observed correlation coefficients with the magnitude of partial correlation coefficient (Mane and Nagesha, 2014). The KMO index ranges from 0 to 1, high values (between 0.5 and 1.0) indicate that factor analysis is appropriate and values below 0.5 imply that factor analysis may not be appropriate because correlation between variables cannot be explained by other variables. (Malhotra and Birks, 2006; Tabachnick and Fidell, 2007; Hair et al., 2010; Mane and Nagesha, 2014). A value close to one indicates factor analysis will yield distinct and reliable factors. A value of 0 indicates that the sum of partial correlations is large in comparison to the sum of correlations, which indicates diffusion in the pattern of correlation, and that factor analysis is inappropriate (De Vaus, 2002). Pallant, (2005) and Field (2009) and Mane and Nagesha (2014) recommended accepting values of 0.5 and Hair et al. (2010) described values between 0.5 and 0.6 as miserable; 0.6 and 0.7 as mediocre, 0.7 and 0.8 as middling, > 0.8 as meritorious and values less than 0.5 are unacceptable. On other hand, Tabachnick and Fidell (2007) suggested 0.6 as the minimum value for a good factor analysis.

The measure of sampling adequacy “MSA” for the individual variables can be found by looking at the diagonal elements in the anti-image correlation matrix. Actually, anti-image correlation is just the negative value of the partial correlation (Hair et al., 2010). Field, (2009) and Hair et al., (2010) indicated that all variables in the anti-image correlation matrix should have MSA value above 0.5. If this requirement is not met, this means that distinct and reliable factors cannot be produced (Yong and Pearce, 2013). Otherwise, in case any variables have MSA < 0.5, it should be removed, and the test should repeated. If many variables have MSA value less than 0.5 then, the variable with the lowest MSA value should be removed for the next run of factor analysis (Hair et al., 2010).

The last control before moving to the principal component analysis is to control that the Bartlett’s test of sphericity. The Bartlett test of Sphericity compares the correlation matrix with a matrix of zero correlations (technically called the identity matrix, which consists of all zeros except the 1’s along the diagonal). This test measures whether the correlations between variables are sufficiently large for factor analysis to be appropriate (Malhotra and Birks, 2006; Field, 2009; Hair et al., 2010). The Bartlett's Test of Sphericity should be significant (p-value < 0.05) for factor analysis to be suitable (Tabachnick and Fidell, 2007; Hair et al., 2010; Mane and Nagesha, 2014).

On the bases of the previous description, this study employed a cutoff point of 0.5 for KMO and MSA. In addition, p-value less than 0.05 considered as acceptable level for the Bartlett's Test of Sphericity. When the value of KMO for the overall variables or MSA for individual variables less than 0.5, the variable with the lowest MSA value has been removed and the factor analysis repeated. This process has been continued by deleting the variable with lowest MSA under 0.5 until all variables obtained acceptable MSA value larger than 0.5. Traditionally, when all variables MSA value larger than 0.5, the KMO will be more than 0.5 accordingly.

## Second phase: Factors extraction

Principal Components Analysis (PCA) is the default method of extraction in many popular statistical software packages, including SPSS and SAS, which likely contributes to its popularity (Costello and Osborne, 2005). Principle Component Analysis (PCA) method is one of the common factors extraction methods and it is commonly adopted as the main objective of conducting the factor analysis is to determine how and to which extent the items are linked to their underlying factors (Zhang et al., 2000; Byrne, 2010). This method will be able to help in identifying if the selected items cluster on one or more than one factor. Principal components analysis is recommended when the primary concern is to determine the minimum number of factors that will account for maximum variance in the data for use in subsequent analysis (Malhotra and Birks, 2006).

There are a lot of advantages in applying PCA. For example, it provides a basis for the removal of redundant or unnecessary items in a developing measure and can identify the associated underlying concepts, domains or subscales of a questionnaire (Rattray and Jones, 2007). In addition, PCA can eliminate the effects of inter-correlated variables and avoid the interactions of subjective factors by changing the original inter-correlated variables into uncorrelated components; and reduce the computing load because each component occurs in descending order of variance. That is, the largest amount of variance of the first component explains the largest amount of variance of the original variables, the second the next largest, and so on (Xundi et al., 2010). Pett et al. (2003) suggested using PCA in establishing preliminary solutions in Exploratory Factor Analysis (EFA). Accordingly, Principal Components Analysis (PCA) has been applied in factor analysis process for this study. The aim of extraction process was to reduce a large number of items into factors.
Several criteria related to factors extraction procedures were proposed by several researchers and they are described below :

1. **Extraction procedure.**

Many extraction rules and approaches exist including: Kaiser.s criteria (eigenvalue > 1 rule), the Scree test, the cumulative percent of variance extracted and parallel analysis ( Malhotra and Birks, 2006; Field 2009 and Williams et al., 2010). Hair et al. (2010) pointed out that the majority of factor analysts typically use multiple criteria. The first two methods have been used commonly in different research, and described as follows:

✓ **Kaiser's criteria (eigenvalue > 1 rule**

The default in most statistical software packages is to retain all factors based on eigenvalues. Eigen value indicates the relative importance of each factor in accounting for the particular set of variables being analyzed (Kothari, 2004). By Kaiser method, a value called eigenvalue under 1 is perceived as being inadequate and therefore unacceptable for factor analysis (De Vaus, 2002; Rattray and Jones, 2007; Byrne 2010; Hair et al., 2010)

✓ **Scree plot**

Alternate tests for factor retention include the Scree plot. Scree plot is a plot of the eigenvalues against the number of factors in order of extraction (Malhotra and Birks, 2006). The Scree test involves examining the graph of the eigenvalues and looking for the natural bend or break point in the data where the curve flattens out. The number of data points above the "break" (i.e., not including the point at which the break occurs) is usually the number of factors to retain, although it can be unclear if there are data points clustered together near the bend (De Vaus, 2002; Malhotra and Birks, 2006; Henson and Roberts, 2006; Hair et al., 2010). Two steps are considered during inspecting and interpreting of the scree plot , as follows (Malhotra and Birks, 2006; Williams, 2010) :

1. Draw a straight line through the smaller eigenvalues where a departure from this line occurs. This point highlights where the debris or break occurs. (If the Scree is messy, and difficult to interpret, additional manipulation of data and extraction should be undertaken.

2. The point above this debris or break (not including the break itself) indicates the number of factors to be retained.

Eigenvalue is the most commonly used technique for factor extraction. Therefore, it was selected for factor extraction in this study. In this method, only the factors having eigenvalues greater than 1 are considered significant; all factors with eigenvalues less than 1 are considered insignificant and disregarded. In addition, Scree plot were provided here for verification of the analysis only.

2. **Number of the factor items**

Not all factors are retained in an analysis, and there is debate over the criterion used to decide whether a factor is statistically important. Traditionally, at least two or three variables must load on a factor so it can be given a meaningful interpretation (Henson and Roberts, 2006). Costello and Osborne (2005) argued that, factor with fewer than three items is generally weak and unstable. As a general guide, rotated factors that have 2 or fewer variables should be interpreted with caution (Yong and Pearce, 2013). A factor with 2 variables is only considered reliable when the these two variables are highly correlated with each another ($r > 0.70$) but fairly uncorrelated with other variables (Tabachnick and Fidell, 2007). Based on the previous assumption, any extracted factor contained less than three variables was removed from analysis during this study analysis.

**3. Communality value**

Communality is the squared multiple correlation coefficient between a variable and all other variables in the analysis. It reveals the percentage of variance in a particular variable that is explained by the factor (Malhotra and Birks, 2006; Field, 2009; Williams et al., 2010). Costello and Osborne (2005) pointed out that uniformly high communalities are unlikely to occur in real data, and 0.4–0.7 should be the common magnitude in social science researches. Velicer and Fava (1998) stated that, item communalities are considered high if they are all 0.8 or greater, which mayn't occur in real data. Hair et al. (2010) has also claimed that communalities less than 0.5 were considered too low, since this would meant that the variable shares less than half of its variability with other variables and have insufficient level of explanation by the extracted factors. It is important to note that if a variable has a communality particularly low (less than < 0.50), then the factor analysis is not accounting for much of the variance associated with that variable which means that the variable does not have much in common with the other variables in the analysis. This may be due to one of three reasons:

1. The variable is distinct and/or very different from the others (not be related to the other items),
2. The measurement of the variable is very unreliable, or
3. An insufficient number of factors were extracted and additional factor that should be explored.

Therefore, variables with communality less than 0.5 were suppressed and removed from the analysis in this study and the factor analysis process repeated. In each run, the communality values of the remaining variables have been investigated and when there were more than one variable with communality value less than 0.5 the variable with the lowest communality values under 0.5 has been removed and the factor analysis processes retuned. Finally, all variables in the last solution should have a communality value equal or more than 0.5 to be accepted.

**4. Factors loading values**

Factor loadings are those values which explain how closely the variables are related to each one of the factors discovered (Kothari, 2004).Typically, factor loading can be considered as a gauge of the substantive importance of a given variable to a given factor as it can be thought of as the Pearson correlation between a factor and a variable (Field, 2009; Mane and Nagesha, 2014). In other words, loading of 0.3, indicates that the factors account for approximately 30% relationship within the data, or in a practical sense, it would indicate that a third of the variables share too much variance (Williams et al., 2010). Hair et al. (2010) indicated the practical significance of the factor loading as follow :

- Factor loadings in the range of ±0.3 to ±0.4 are considered to meet minimal level for interpretation of the structure.
- Factor loadings ±0.5 or larger are considered practically significant.
- Factor loadings exceeding ±1.7 are considered indicative of well-defined structure and the goal of any factor analysis.

Stevens (2002) stated that the significance of a factor loading will depend on the sample size. A table of critical values were produced against which loadings can be compared. To summarize, he recommends that for a sample size of 50 a loading of 0.722 can be considered significant, for 100 the loading should be greater than 0.512, for 200 it should be greater than 0.364, for 300 it should be greater than 0.298, for 600 it should be greater than 0.21, and for 1000 it should be greater than 0.162. Tabachnick and Fidell (2007) cited 0.32 as a good rule of thumb for the minimum loading of an item, which equates to approximately 10% overlapping variance with the other items in that factor. Kothari (2004) reported that a low loading level of 0.33 is considered adequate in exploratory studies. Mane and Nagesha (2014) used a factor loading above 0.5 in extracting the factors included in their study. Other researchers take a loading of an absolute value of more than 0.3 to be important (Field, 2009). After completing the rotation, a cut off point for factor loading has been selected in this study. Generally, there is no hard and fast rule for deciding the cutoff point but commonly it is chosen above 0.5 (Pallant, 2005), and the same is adopted in this study as well. Thus, variables with a loading of 0.5 and above are obtained and employed for naming and interpreting the extracted factors.

Henson and Roberts (2006) concluded that, researcher needs to decide about the deletion of a cross loading item, which is an item/variable may have several adequate factor loading values (generally, 0.50 or better) on two or more factors in the rotated solution. Hair et al. (2010) argued that, any variable having more than one significant loading (equal or more than 0.5) on the extracted factor become a candidate for deletion from the analysis. Clearly, if there are several cross-loaders, the items may be poorly written or the a priori factor structure could be flawed (Henson and Roberts, 2006). In this study, items that were cross loaded on multiple factors are deleted and factor analysis process has been retuned (De Vaus, 2002). Factor loadings of 0.5 or more for was the cutoff value used in this study to delete items.

### 5. Cumulative Percentage of Variance

One measure of a good factor analysis is the amount of the total variance in the original set of variables that is explained by the factors. The greater the explained variance, the better the solution (De Vaus, 2002). For instance, in the natural sciences, according to Hair et al. (2010), the explained variance is generally as low as 50-60%. It is recommended that the factors extracted should account for at least 60% of the variance (Malhotra and Birks, 2006). Meyers et al. (2006) have suggested that the component solution should explain at least 50% of the total variance. Accordingly, the extracted solution will be accepted in this study only when the percentage of the explained variance from the extracted factors was more than 50%. According to De Vaus (2002), when the explained variance lower than 50%, the variable/item with the lowest value of communality dropped from analysis to increase the total variance explained and factor analysis repeated in the next run.

All data related to factor extraction can be shown in total variance explained table. The components (factors) in this table are arranged in the descending order based on the most explained variance. The Extraction Sums of Squared Loadings is identical to the Initial

Eigenvalues except factors that have eigenvalues less than 1 are not shown. These columns show the eigenvalues and variance prior to rotation. The Rotation Sums of Squared Loadings show the eigenvalues and variance after rotation.

### Third Phase: Factor rotation and interpretation

Another consideration when deciding how many factors will analyze the study data is whether a variable might relate to more than one factor. Rotation maximizes high item loadings and minimizes low item loadings, therefore producing a more interpretable and simplified solution ( Rattray and Jones, 2007). The main purpose of rotation is to bring the smallest loadings close to zero and its largest loading towards unity (Mane and Nagesha, 2014). There are two common rotation techniques: orthogonal rotation and oblique rotation (Williams, 2010). If there are theoretical grounds to think that the factors are independent (unrelated) then it is advisable to choose one of the orthogonal rotations (varimax is recommended). However, if theory suggests that factors might correlate, then one of the oblique rotations (direct oblimin or promax) should be selected (Field, 2009).

Despite of this, one can argue that varimax rotation is the best method in order to create more interpretable clusters of factors. Orthogonal Varimax rotation first developed by Thompson (2004), is the most common rotational technique used in factor analysis, which produce factor structures that are uncorrelated. Varimax attempts to maximize the dispersion of loadings within factors. Therefore, it tries to load a smaller number of variables highly onto each factor resulting in more interpretable clusters of factors (Field, 2009). In essence, the solution obtained through varimax rotation produces factors that are characterized by large loadings on relatively few variables (Kothari, 2004). On the basis of this argument, this study has chosen the Varimax method for rotation.

### Fourth: Reliability of constructs (Cronbach alpha)

By utilizing factor rotation, one has established that there are a number of constructs that consists of more than one variable. Before concluding that variables can be founded by the factors found in the rotated component matrix, one should also measure the reliability of these factors. One way of testing the consistency between the items in each factor is through the Cronbach's alpha test. The Cronbach's alpha is based on the average inter-item correlation. According to Pallant (2005), a scale with a Cronbach's alpha higher than 0.7 is required in order to create a reliable construct of multiple variables. Although 0.60 level can be used in exploratory studies (Hair et al, 2010). Therefore, Cronbach alpha with 0.6 or more for each variable and factor in the final solution can be considered acceptable in this study.

### Fifth Phase : Factors interpretation and labeling.

Interpretation involves the researcher examining which variables are attributable to a factor, and giving that factor a name or theme (Henson and Roberts, 2006; Williams et al., 2010). The labelling of factors is a subjective, theoretical, and inductive process (Pett et al., 2003). It is important that these labels or constructs reflect the theoretical and conceptual intent. Naming of factors is more of an 'art' as there are no rules for naming factors, except to give names that best represent the variables within the factors(Yong and Pearce, 2013).

Naming the principal factors was done in line with Hart's (2008) recommendations, which suggests that the factor names should be brief (one or two words) and communicate the nature of the underlying construct. This was done by looking for patterns of similarity between items that load on a factor. In addition, looking at what items do not load on a factor, to determine what that factor is not. Also, try reversing loadings to get a better interpretation (Field, 2009; Williams et al., 2010). Hart (2008) recommended to use a questionnaire with experienced individuals to validate the names of the factors for research.

***Summary of the adopted statistical procedures for factor analysis***

Exploratory factor analysis (EFA) can be viewed as a data reduction technique which will identify latent factor and reduces large set of variables to a couple of underlying factor. EFA was applied to specific variables of several fields of questionnaire, in order to eliminate the incompetent and inadequate variables (questions) and to explore if all questions of each construct are properly measuring what they supposed to. To do so, first order factor analysis was performed and identified and the items that violates the main criteria of factor analysis have been deleted one by one which were reported later (communality> 0.5 , factor loading > 0.5 , no cross loading, etc.,). Then, several runs of exploratory factor analysis was carried out on the remaining variables till all requirements of factor analysis are satisfied and the extracted factors were determined the reduced data set of each field. These processes were performed with SPSS analytical tool.

### B. Inferential statistics:

The function of inferential statistics is to provide an idea about whether the patterns described in the sample are likely to apply in the population from which the sample is drawn (De Vaus, 2002). It is concerned with the various tests of significance for testing hypotheses in order to determine with what validity data can be said to indicate some conclusion or conclusions (Kothari, 2004). Inferential statistics assess the probability that an observed difference is not just a fluke or chance finding. It is about conducting statistical tests that can show statistical significance (Marczyk et al., 2005). The terms parametric statistics and nonparametric statistics refer to the two major groupings of statistical procedures (Singh, 2006; Preston, 2012). Generally, the first step in performing inferential statistics is to decide the type of the tests to be conducted (parametric or non-parametric). The tests type to be selected will be based on the distribution of the data included in analysis.

#### I. Parametric tests

While Likert scale data have been considered as ordinal scale data, a great number of papers in international journals using Likert scales in their questionnaire surveys have adopted parametric statistical methods. A parametric test is a statistical test based on several assumptions about the parameters of the population from which the sample was drawn (Naoum, 2007). Meanwhile, the results from parametric methods with ordinal data were recognized as reasonably reliable. These parametric methods included, but are not limited to: t-test, multiple regression and Pearson correlation (Carifio and Perla, 2008). In addition, some previous studies argued that parametric methods for interval variables could be used for ordinal variables because the power and flexibility obtained from parametric methods can outweigh the small biases that they may entail (Allen and Seaman, 2007).

Normal distribution is an important expression in the field of statistics because the selection of some inferential statistics depends on whether the data is normally distributed or not (Naoum 2007). Parametric statistics are based on the assumption that the data in the study are drawn from a population with a normal distribution and/or normal sampling distribution (Preston, 2012). Norman (2010) argued that parametric statistics can be used to analyze Likert data with unequal variances and non-normal distributions, without fear of coming to wrong conclusions. According to Hair et al (2010), when the sample size is more than 30, the central limit theorem shows that a normal distribution can be assumed. On other hand, Elliott and Woodward (2007) indicated that normality assumption can be recognized when the sample size is 40 or more. Field (2009) also argues that with a sample size of more than 50, the sampling distribution will almost always approach normal distribution albeit considering the size of the sampling frame or population. Therefore, with a sample size of 76 in this study which is bigger than 30, it can be assumed that the sampling distribution is normally distributed and parametric analysis of ordinary averages of Likert scale data is justifiable by the Central Limit Theorem. Therefore, this study adopts Pearson's correlation coefficient, one sample t-test, etc., to analyze the data.

### II. Nonparametric tests

Nonparametric methods are used when the researcher does not know how the data are distributed. (Preston, 2012). Thus, nonparametric statistics are referred to as distribution free (Zikmund et al., 2009). They are used when the variables are non-metric and they are available for testing variables from one sample, two independent samples, or two related samples (Malhotra and Birks, 2006). The basic technique used by nonparametric procedures to get around the normality assumption is that they do not use the raw data. Instead, in a nonparametric procedure, the ordered or ranked values are used in the analysis (Elliott and Woodward, 2007). Singh (2006) stated that, the variables in a non parametric tests are usually presented in rank order or discrete values. The most common non-parametric statistics are, the Mann–Whitney test, the Wilcoxon signed-rank test, Friedman's test and the Kruskal–Wallis test (Field, 2009). Naoum (2007) concluded that, the assumptions associated with most non-parametric tests are weaker than those associated with parametric tests.

#### ❖ Pearson Correlation Coefficient

Pearson's correlation coefficient (r) is a parametric test which is used to calculate whether there is a strong relationship between two sets of scores (Naoum, 2007; Creative research system, 2014). Pearson's coefficient of correlation is also known as the product moment correlation coefficient and indicates both the magnitude of the linear relationship and the direction of that relationship (Elliott and Woodward, 2007). The value of 'r' lies between ± 1. Positive values of r indicate positive correlation between the two variables (i.e., changes in both variables take place in the statement direction), whereas negative values of 'r' indicate negative correlation i.e., changes in the two variables taking place in the opposite directions.

A zero value of ‘r’ indicates that there is no association between the two variables (Kothari, 2004; Preston, 2012). A whole set of correlations can be presented in a very efficient fashion by using correlation matrices (De Vaus, 2002). A correlation matrix (R- matrix) is the standard form for reporting observed correlations among multiple variables (Preston, 2012).Two directions can be inferred from the correlation coefficient as described by Marczyk et al. (2005) as follows;

- **Positive correlation*:*** A positive correlation between two variables means that both variables change in the same direction.
- **Negative (inverse) correlation*:*** A negative correlation between two variables means that as one variable increases, the other variable decreases. In other words, the variables change in opposite directions.

Most statistics packages quote a t-statistic along with the correlation coefficient for purposes of testing whether the correlation coefficient is significantly different from zero (Elliott and Woodward, 2007). The usual hypotheses for testing the statistical significance of a Pearson’s correlation coefficient are the following: (De Vaus, 2002)

- ✓ $H_0$: r= 0 (there is no linear relationship between the two variables).
- ✓ *Ha*: r ≠0 (there is a linear relationship between the two variables).

The test statistic is given by: $t_{test} = r\ (n - 2)/(1 - r^2)$. The critical value is $t_{critical}$ for a chosen significance level (α = 0.05) and (n – 2) degrees of freedom. The null hypothesis is rejected if $t_{test} > t_{critical}$.

Although there are no hard and fast rules for describing correlational strength. As a rule of thumb, in social sciences a correlation of 0.30 might be regarded as relatively strong (De Vaus, 2002). In this study, Pearson’s correlation coefficient has been used in several cases to infer information about relationship between the variables. In special, it was used to prepare the correlation matrix to decide the data suitability for factor analysis.

- ❖ **Test of significance.**

Traditionally, researchers have specified an acceptable significance level for a test prior to the analysis. A significance level is a critical probability associated with a statistical hypothesis test that indicates how likely it is that an inference supporting a difference between an observed value and some statistical expectation is true. The term p-value stands for probability-value and is essentially another name for an observed or computed significance level (Preston, 2012). Generally, test of significance produces a p-value (probability value) between 0 and 1 (De Vaus, 2002). The rejection or acceptance of a null hypothesis is based upon some level of significance as a criterion. The 5 per cent level of significance (0.05) is often accepted as a standard for rejection (Malhotra and Birks, 2006; Singh, 2006). The conventional level by which the null hypothesis can be rejected and conclude that the results are significant is, $p < 0.05$ (Elliott and Woodward, 2007).

Otherwise, the results of the test are not significant and null hypothesis should be accepted to indicate that no relationship or association between the research variables or issues under investigation (Naoum 2007). An alternative way to test the hypothesis is to formulate the decision rule in terms of the t-statistic (Preston, 2012). For that, when the samples are large (more than 30) the critical ratio is expressed as tcritical that lies exactly on the boundary of the region of rejection (Singh, 2006). Normally, if the value of the calculated t statistic is larger than the critical value determined, the null hypothesis "H0" reject. If the calculated value is smaller than the critical value, do not reject H0 (Malhotra and Birks, 2006).

Test of significance has been employed in different places in this study, especially, to ascertain the significance and importance of the variables included in study (such as awareness feature, application requirement and etc.,). In addition, this test has been employed to test the significance of the correlation between two variables. The significance level p-value was specified at 0.05 and the critical t-value equals to 1.99 for two tailed tests .

- **One sample t-test**

The t-test is a parametric test which is used to compare the difference between the mean scores of two samples.(Zikmund et al., 2009; Naoum 2007). Elliott and Woodward (2007) argued that, a standard assumption for the *t*-test to be valid when there are small sample sizes is that the outcome variable measurements are normally distributed. Data analysis (involving one-sample t-test) reveals some interesting findings in regard to how the respondents perceive the importance of the adopted variables in the questionnaire to measure what is expected to measure. A one sample t-test allows to test whether a sample mean significantly differs from a hypothesized value. It is carried out to determine whether the population considered a specific attribute to be important or otherwise. The proposed null hypothesis was that the item was unimportant and the alternative hypothesis was that the item was important. The significance level set at 5% in accordance with conventional risk levels (Field, 2009).

If the p-value less than 0.05, the variable can be considered important with the probability of 95%. Hence, one sample t-test in this study has been used to test whether each listed variable n study considered by participant to be important or not. It was used to test whether mean score of a factor is significantly above the average score of 3.00 at 5% significance level (Ofori et al., 2002). When $p < 0.05$ and the t-value are positive, it is concluded that there is significantly good relationship quality among contracting parties or there is significant agreement that an item affects the subject under study (such as, awareness level, application level, driving level, and etc,). In a typical one-sample-test, the mean of the test group, the t-value (which is an indication of the strength of the test) and the p-value (i.e. the probability value that the test is significant) are commonly reported (Field, 2009; Hair et al, 2010).

### 3.4.4 Fourth phase: Writing the research report

This stage involved the writing up of the full research report on the selected topic by summarizing the complete work in the abstract, critically analyzing existing practices /trends in the selected topic and presenting the findings of the literature review. Research report is considered a major component of the research study for the research task remains incomplete till the report has been presented and/or written (Kothari, 2004). It is generally produced in the written 'form' and is called research report or thesis. A detailed description of research activities are provided in it (Singh, 2006). The characteristics of the research types, method of analysis chosen, and analysis of the results obtained from the industry professionals are also described and at the end conclusions and recommendations are presented in the final chapter. In general, analysis of the results, the abstract, the conclusion and recommendations and the references prepared in this stage. Harvard style is the common method of referencing in different researches and it was used in this study for referencing.

***Summary of research method***

This chapter has presented an outline of the research methodology adopted for carrying out this research. Combinations of methods were adopted to enable an in depth study of the energy management program in contracting organization, which helped to achieve the research aim and objectives. This involved first, a comprehensive literature review followed by a pilot survey for fine-tuning the questionnaires for a subsequent survey to investigate local contractors awareness and application levels regarding the concept of energy management and the key activities, drivers and associated barriers towards implementing it. The response from the different construction professionals through administrated questionnaire survey provided their general opinions and views on the research objectives. The data collected were analyzed, with the aid of SPSS V.22, using a variety of statistical methods including descriptive statistics, relative index analysis, Cronbach alpha, Pearson correlation, t-tests and factor analysis.

Information gathered from literature review, the survey and subsequent interviews was used to draw deductions and conclusions in respect of the research objectives. In addition, the data collected from the survey were analyzed and discussed in next chapter and is presented in figures, tables and charts.

Table (3.19): Research process summary

| Research task | Purpose | Outcome |
|---|---|---|
| **First research phase: Information gathering** | | |
| Formulating the research problem | ➢ Identify the issue and problem;<br>➢ Establish aim, objectives, and key research questions.<br>➢ Selecting research approach<br>➢ Selecting research strategy | ➢ **Research issue and problem**<br>1- Construction contractors in Gaza Strip working without any considerations relating to environmental issues especially, which related to efficient energy use, saving and management.<br>2- Very little or no investigations and studies have been pointed out the problems, components or strategies that are related to energy management in local construction sector.<br>➢ **Research aim**<br>To create an understanding of how energy issues are managed during the construction process in construction contracting firms working in Gaza Strip.<br>➢ **Research objectives**<br>1- To assess the local contractors level of awareness about energy issues and energy management in construction industry.<br>2- To identify the degree of practice of energy saving and management during construction process in local contracting firms.<br>3- To explore the major drivers enhancing the local contractors to adopt energy management during project construction.<br>4- To identify the key barriers to the implementation of energy management in local contracting companies during the project construction.<br>5- To pinpoint the contractor best activities to reduce energy consumption during the project construction .<br>➢ **Research approach**<br>Quantitative research was selected.<br>➢ **Research strategy**<br>Structured questionnaire was selected. |

Table (3.19): Research process summary "Continued"

| Research task | Purpose | Outcome |
|---|---|---|
| Extensive literature review | ➢ Introduce an overview of the energy management and related concepts.<br>➢ Collecting of several factors/parameters which are related to the area of investigation.<br>1. Identifying energy management awareness feature.<br>2. Identifying energy management application requirements.<br>3. Identifying energy management application drivers.<br>4. Identifying energy management application barriers.<br>5. Identifying best activities to save energy.<br>➢ Review research methodologies, data collection and analysis methods conducted by other researchers in the same subject area | ➢ **Energy management overview.** Provide definitions and main components about sustainability, energy management, green construction, sustainable construction and etc.<br>➢ **Initial research factors. (Appendix C)**<br>➢ 13 energy management awareness features were collected from 28 references.<br>➢ 26 energy management application requirements were collected from 18 references.<br>➢ 50 energy management adoption drivers were collected from 26 references.<br>➢ 159 energy management adoption barriers were collected from 29 references.<br>➢ 86 energy saving activities were collected from 21 references<br>➢ **Review previous research methodologies.** Research methodology , data collection and data analysis methods for more than 40 previous studies were reviewed (Table 3.1) |
| Preliminary interviews | ➢ Fine tune the preliminary lists of the collected factors.<br>➢ Validate the results of the literature review.<br>➢ Preparation of the basic data to construct the draft questionnaire. | ➢ Initial factors revision and validation resulted in the following outcomes: (Appendix D)<br>➢ 10 energy management features were emerged.<br>➢ 17 energy management application requirements were emerged.<br>➢ 26 energy management application drivers were emerged.<br>➢ 31 energy management application barriers were obtained.<br>➢ 33 energy saving activities were obtained. |

Table (3.19): Research process summary “Continued”

| Research task | Purpose | Outcome |
|---|---|---|
| **Second research phase: Research design** | | |
| Sample design and sampling procedures | ➢ Defining study population<br>➢ Identifying sampling units<br>➢ Describing sampling elements<br>➢ Identifying sampling frame<br>➢ Determining sample size<br>➢ Selecting sampling procedure | ➢ **Defining study population.**<br>Study population consists of main contracting companies of working in Gaza Strip.<br>➢ **Identifying sampling units**<br>First, second and third class of local contracting companies forming the sampling unit.<br>➢ **Describing sampling elements**<br>Sampling unite involved projects managers and site engineers in local contracting companies.<br>➢ **Identifying sampling frame**<br>P.C.U directory listing data about the valid firms in an local construction industry from the first to third classes.<br>➢ **Determining sample size**<br>Sample size of this study was 100 respondents, 41 from first class, 37 from second class and 22 from third class.<br>➢ **Selecting sampling procedure.**<br>Stratified random sampling method adopted to select a representative sample. |
| Format of questionnaire questions | ➢ Proposing the format for the questionnaire questions. | Closed questions used in formatting questionnaire questions. |
| Data measurement technique | ➢ Identifying scale of measurement<br>➢ Specifying scaling technique | ➢ **Identifying scale of measurement**<br>- **Nominal scale** used for the first part of the questionnaire related to the respondents information.<br>- **Ordinal scale** were adopted to measure the respondents perception about their awareness and knowledge on energy management, their level of application, drivers to adopt energy management, barriers to energy management application and the best energy saving activities.<br>➢ **Specifying scaling technique.**<br>Rating scale involved 5 points Likert scale where used to measure the respondents level of agreement about each statement. |

Table (3.19): Research process summary "Continued"

| Research task | Purpose | Outcome |
|---|---|---|
| Questionnaire design | ➢ Identify the contents of the draft questionnaire.<br>➢ Conducting questionnaire pre-field pretesting.<br>➢ Conducting field testing "pilot study"<br>➢ Finalizing the study questionnaire. | ➢ **The first draft questionnaire was established to include the following six sections:**<br>- **Section 1 :** Respondent and company general information.<br>- **Section 2 :** Local contractors level of awareness/knowledge of energy management.<br>- **Section 3 :** Local contractors degree of practice of energy saving and management in the construction projects.<br>- **Section 4:** The major drivers enhancing local contractors to adopt energy management during project construction.<br>- **Section 5:** The key barriers to the implementation of energy management in the contracting companies of Gaza Strip.<br>- **Section 6:** The best energy management activities to save energy during project construction.<br><br>➢ **Conducting questionnaire pre-field pretesting.**<br>1- Testing the draft questionnaire with eight experts in construction and energy to prepare the semi-final questionnaire.<br>2- Testing the semi-final questionnaire with 6 experts in construction and energy subjects to prepare the final version of questionnaire.<br>3- The tested semi-final questionnaire was modified to prepare the second version of the semi-final questionnaire in the third run of pretesting.<br>4- Final pre-field testing of the semi-final questionnaire to prepare the final questionnaire.<br><br>➢ **Conducting field testing " Pilot study"**<br>20 samples were selected randomly from the collected questionnaire and tested;<br>1- Testing questionnaire validity "content validity; criterion-related validity and construct validity"<br>2- Testing questionnaire reliability by Half Split method and Cronbach's Alpha coefficient method. |

Table (3.19): Research process summary “Continued”

| Research task | Purpose | Outcome |
|---|---|---|
| | | ➢ **Finalizing the study questionnaire.**<br>Questionnaire results from pretesting in profiled and pilot study and accepted for experts was distributed and the pilot study conducted statistically on 20 samples of collected questionnaires. |
| **Third research phase: Main data collection** | | |
| Questionnaire distribution & collection | ➢ Select method of distribution<br>➢ Determine the number of collected questionnaire<br>➢ Determine the number of valid questionnaire<br>➢ Determine response rate | ➢ **Questionnaire distribution method**<br>Self-administration method was used to distribute final questionnaire to 100 individual from contracting companies .<br>➢ **Determine the number of collected questionnaire**<br>86 questionnaire were returned .<br>➢ **Valid questionnaire**<br>10 questionnaires from the collected found to be not complete and invalid for analysis.<br>➢ **Response rate**<br>(76/271005)*100 = 76 % |
| Data analysis | ➢ Select analysis program.<br>➢ Identify method of analysis<br>➢ Prepare all analysis tables discussion. | ➢ **Analysis Program**<br>IBM (SPSS) version 22<br>➢ **Method of analysis**<br>Quantitative analysis<br>➢ **The quantitative analysis types**<br>**A. Descriptive Statistics:**<br>1. Frequencies and Percentile (results can be presented in the form of tabulation,<br>2. measures of central tendency (The mean)<br>3. Measurement of dispersion based on the mean (standard deviation)<br>4. Average index method<br>5. Relative Important Index (RII)<br>6. Factor analysis<br>**B. Inferential statistics:**<br>1. Pearson product-moment correlation coefficient/ Pearson's correlation coefficient )a parametric test<br>2. One sample t-test |

Table (3.19): Research process summary "Continued"

| Research task | Purpose | Outcome |
|---|---|---|
| **Fourth research phase : Writing the research report** | | |
| Writing the research report | ➢ Prepare the final questionnaire report | The questionnaire report were collected and refined to include five chapters and many appendices :<br>- Abstract<br>- Table of contents<br>- Chapter 1 : Introduction<br>- Chapter 2: Literature review.<br>- Chapter 3: Research methodology<br>- Chapter 4: Data analysis and discussion.<br>- Chapter 5: Conclusion and recommendations.<br>- Appendices<br>- Reference |

Chapter 4

# Data analysis & Discussion

This chapter provides a clear description and in-depth discussion about the analysis results gathered from the collected questionnaires.

## 4.1 Respondent's profile.

The importance of demographic information cannot be undermined for a meaningful quantitative analysis. Background and general information from the respondents were also soughed. As the aim of research are focused on the construction phase of the project, so it was targeted contracting organizations because they are the key player of construction project team and the respondents having satisfactory professional experience. The questionnaires should be filled by the experienced individuals only working as projects managers or site engineers. Their opinions and views are quite important and reliable in order to establish the findings. This section presents brief background information of the survey respondents data as shown in Table (4.1).

Data provided in Table (4.1) illustrates that 22.4% of the respondents are highly educated with postgraduate studies which emphasizes what is known about the Palestinian contractors that most of them are engineers, and this indicates their awareness of the importance of education and improvement. The respondents persistence and their capabilities of surviving can be validated as most of the respondents in this study have experience above 5 years. In addition, the points of view of the surveyed individuals are expected to be convergent. Concerning the company experience, it can be seen that most contracting companies participating in this study have a satisfactory experience in construction industry more than 5 years. So that , more accurate responses can be obtained as they easily understand the contents of this study questionnaire.

Size of the participated companies was determined by asking respondents to indicate the number of employees in their organization. It can be shown that the majority of respondents worked in contracting organizations belong to either small or medium sized organizations, as the fixed workers ranged between 11 to 50. It is worth noting that, local contracting organizations depends on temporary employment, so that number of fixed employees may not reflect the company size. Also, local contracting companies depend on hiring subcontractors in the construction projects to execute projects. Results also indicated that respondents had worked in different types of projects especially, residential, and Infrastructure. In fact, major valid local contracting companies as registered in PCU are classified under these two fields of works. Table (4.1) demonstrates that the highest percentage response was from first class which reflects their interest in the subject of the study or simply it may reflect their attitude toward every opportunity for development. In the same line, This results increases the credibility and reliability of the results.

Table (4.1): Respondent's profile

| Information about respondents | Categories | Frequency | Percentage |
|---|---|---|---|
| Education level | Bachelor | 59 | 77.6% |
| | Postgraduate studies | 17 | 22.4% |
| Respondent experience in the construction works | From 1 to less than 3 years | 3 | 3.9% |
| | From 3 to less than 5 years | 12 | 15.8% |
| | From 5 to less than 10 years | 34 | 44.7% |
| | More than 10 years | 27 | 35.5% |
| Company classification class | Third class | 16 | 21.1% |
| | Second class | 30 | 39.5% |
| | First class | 30 | 39.5% |
| Company experience in the construction industry | From 1 to less than 3 years | 1 | 1.3% |
| | From 3 to less than 5 years | 5 | 6.6% |
| | From 5 to less than 10 years | 28 | 36.8% |
| | More than 10 years | 42 | 55.3% |
| Company size ( number of employees) | Less than 10 employees | 12 | 15.8% |
| | From 11 to 30 employees | 35 | 46.1% |
| | From 31 to 50 employees | 25 | 32.9% |
| | More than 50 employees | 4 | 5.3% |
| Types of implemented projects through company in the last ten years | Residential | 32 | 42.1% |
| | Infrastructure | 34 | 44.7% |
| | Public buildings | 9 | 11.8% |
| | Environmental | 1 | 1.3% |
| Number of executed projects in the last 10 years | 10 Projects or less | 23 | 30.3% |
| | 11-20 Projects | 36 | 47.4% |
| | 21-30 Projects | 16 | 21.1% |
| | More than 30 projects | 1 | 1.3% |
| Value of executed projects during the last five years (Million dollars) | From 1 to less than 2 | 13 | 17.1% |
| | From 2 to less than 5 | 40 | 52.6% |
| | More than 5 | 23 | 30.3% |

## 4.2 Degree of awareness of energy management in local construction sector.

The first objective of this study was proposed to assess the local contractor awareness level about energy management to save energy during construction phase. To achieve this objective, the second part of questionnaire was framed in such a way to get general views of the respondents on the aspects and features of sustainability and energy management. Table (4.2) depicts the general awareness and knowledge of the respondents with regard to the sustainability and energy management features. In order to gain an insight into the level of awareness and knowledge among construction contractors with regard to the concept of energy management and sustainability, the respondents were asked to rate their agreement about the accuracy of each one for this subject matter and their perception of it, based on their experience and level of understanding on the subject.

Ten sustainability and energy management awareness features (AEM1 to AEM10) were identified from the precedent literature and data collection process as the potential areas to measure the awareness level on energy management in construction. The mean score (MS), standard deviation (SD), t-test results, average index indicator and ranking order calculations on the respondents level of agreement with different features of energy management awareness in construction industry are shown in Table (4.2). The mean score (MS) values of the respondents agreement about the features can measure the degree of awareness about energy management on the basis of average index indictors method discussed in depth in chapter three which identified the indices for each item according to specified mean score boundaries ("very high for $4.50 \leq MS \leq 5.00$", "high for $3.50 \leq MS < 4.50$", "average for $2.50 \leq MS < 3.50$", "low for $1.50 \leq MS < 2.50$" and " very low for $0.00 \leq MS < 1.50$") and these indices proposed and used in several studies such as, Wai et al. (2011), Mohamad et al. (2012) and Memon et al. (2014). So that, the mean scores gained from questionnaire about energy management awareness features were compared with the average index assessment scale which provided assessment indicator for each one of these features. Mean scores of the used features are presented in Figure (4.1) and their ranking hierarchy on the basis of their significance in reflecting level of awareness about energy management is tabulated in Table (4.2).

In this study, one-sample t-test has been performed to examine whether the ten features identified in this research can reflect the degree of awareness about energy management. It is shown from Table (4.2) that nine feature from the listed ten features have p-value less than the significance level of (0.05). Also, these nine features has a t-value larger than the critical t-value (1.99). Accordingly, these nine features can be considered significant in measuring the level of awareness about energy management concept. In addition, from these nine feature, only seven features with positive t-value which mean that these seven features means are larger than the hypnotized mean (larger than 3) which indicated that the respondents agreed about these features. This result was based on Webb et al. (2006) conclusion which reported that when mean scores are above the criterion mean, it can be generalized and therefore it is an indication that the data set are in agreement with the upper scale of the Likert scale. It is worth noting, the other two features which are *"GHG emissions are the highest negative environmental impact associated with energy use during onsite* *construction" AEM3*, with (p-value=0.00 and t-value= -3.81) and *"Onsite energy costs represent an important part of the project overall costs" AEM1* with (p-value=0.01 and t-value= -2.81), negative t-value mean that these features mean values less than the hypothesized value (equal to 3) and they were found to be statistically significant ($p \leq 0.05$) and with absolute t-value larger than the critical t-value (1.99). This appears to suggest that, although these two features might not necessarily qualify as major to reflect awareness level about energy management in the construction industry; they should be noted as quiet significant in the context of the Gazan contractors organizations.

However, only the feature *"Energy management is one of the construction business ethics" AEM8*, with p-value larger than 0.05 and with negative t-value less than the critical value (1.99). Therefore, it seems that this feature is not significant with regard to energy management awareness. Although this feature believed in general to has the potential for indicating the awareness level of energy management (Glavič and Lukman, 2007; Kibert, 2008), in the Palestinian context, construction contractors didn't consider it as a critical feature. This provides informative evidence that local construction contractors might need to reconsider their current perceptions about this feature as not a critical feature to measure degree of awareness about energy management.

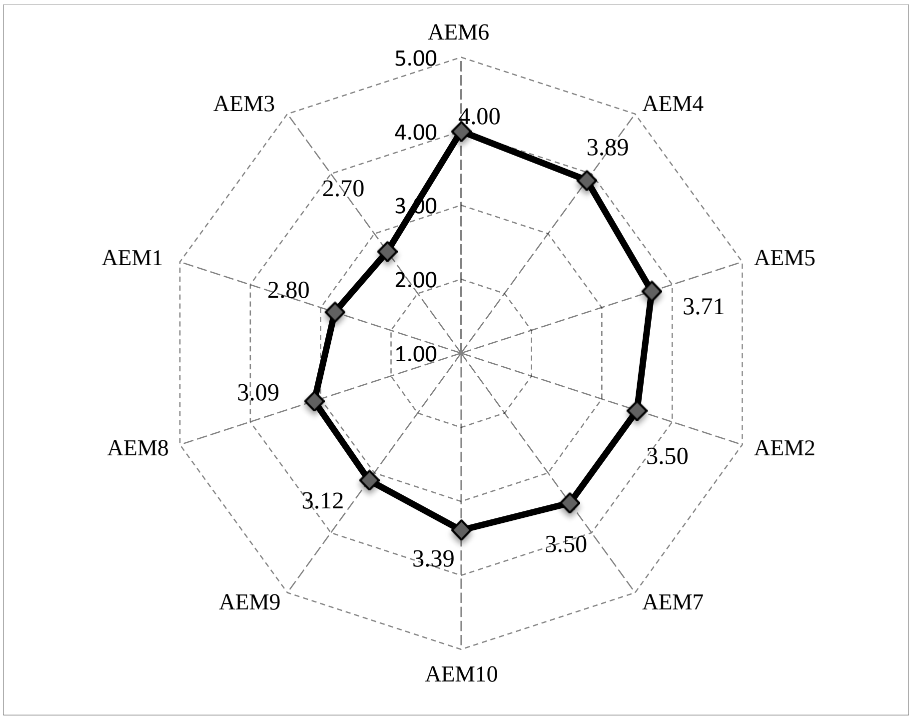


Figure (4.1) : Mean scores of energy management awareness features *"AEM1 to AEM10"*

Table (4.2): Respondents level of agreement about energy management awareness features.

| No. | Energy management awareness criteria | MS | SD | t-value | P-value (2-tailed) | Average Index Indicator | Rank |
|---|---|---|---|---|---|---|---|
| AEM6 | Energy management improves the company performance (competitive advantage). | 4.00 | 0.88 | 9.91 | 0.00 | High | 1 |
| AEM4 | There is energy efficiency gap in local construction industry. | 3.89 | 0.89 | 8.78 | 0.00 | High | 2 |
| AEM5 | Energy management is one component of the sustainability concept. | 3.71 | 0.88 | 7.07 | 0.00 | High | 3 |
| AEM2 | Increased onsite energy use may result in different negative environmental impacts. | 3.50 | 0.76 | 5.76 | 0.00 | High | 4 |
| AEM7 | Adoption of onsite energy management affects the project management method/style. | 3.50 | 0.55 | 7.87 | 0.00 | High | 5 |
| AEM10 | Energy management highly reduces the negative environmental impacts of the project. | 3.39 | 0.73 | 4.70 | 0.00 | Average | 6 |
| AEM9 | Energy management highly reduces overall project cost. | 3.12 | 0.54 | 3.91 | 0.04 | Average | 7 |
| AEM8 | Energy management is one of the construction business ethics. | 3.09 | 0.44 | 1.84 | 0.07 | Average | 8 |
| AEM1 | Onsite energy costs represent an important part of the project overall costs. | 2.80 | 0.61 | -2.81 | 0.01 | Average | 9 |
| AEM3 | GHG emissions are the highest negative environmental impact associated with energy use during onsite construction. | 2.70 | 0.69 | -3.81 | 0.00 | Average | 10 |
| | Overall awareness features | 3.37 | 0.48 | 6.79 | 0.00 | Average | - |

- *MS: Mean Score* *SD: Standard Deviation*
- *Critical t-value (two-tailed): at degree of freedom (df) = [N-1] = [76-1] = 75 and significance level 0.05 equals "1.99"*
- *The hypothesized population mean is the critical rating at 3.*

From the previous results on t-test, it can be seen that, the overall average of these features is (MS=3.37) and it is greater than the hypnotized mean (equal to 3). In addition, the collective (p-value=0.00) for all features is less than significance level (0.05), hence, it can be concluded that the respondents' sample already accepted these features as a significant awareness features about energy management that should be taken into account to measure the level of energy management awareness.it can be concluded that all the ten factors have effects energy management awareness. Furthermore, the fact that the standard deviations for all features are less than 1.0, indicated that there was little variability in the data and consistency in agreement among the respondents in how those features were interpreted (Wai et al., 2011).

The mean scores (MS) for the listed features about energy management ranges from 2.7 to 4 with overall mean score (MS=3.37). So that, these results demonstrate that the respondents have an average to high degree of agreement about the features included in the study, with an overall awareness level corresponds with average agreement about all listed features ( 2.50 ≤ "Overall MS =3.37"< 3.50 ). Five out of ten features have average agreement according to adopted average index indicator with (2.50 ≤ "MS"< 3.50), the other five criteria have high agreement according to adopted average index indicator with (3.50 ≤ "MS"< 4.50). This variability in awareness indicators indicated that local construction companies didn't fully understand energy management in construction industry. The major observation that can be drawn is that the local construction contractors in Gaza Strip have a moderate degree of awareness about energy management. These results are logic as the respondents of this study come from professional and managerial positions, who have acceptable technical experience and educational background.

The top three criteria were "*Energy management improves the company performance (competitive advantage)"AEM6*, "*There is energy efficiency gap in local construction industry" AEM4* and "*Energy management is one component of the sustainability concept" AEM5*. From Table (4.2), it has been found that *"Energy management improves the company performance (competitive advantage)" AEM6,* was ranked as the first awareness feature known to the respondents with (MS=4, SD= 0.88 and p-value=0.00), which lies into high agreement indicator category. This result illustrates the extent of the local construction companies' awareness of the importance and impacts of the energy issues development on the firm performance and indicates management awareness of positive effects resulting from the application of energy management. This result clearly confirms the assertion of Pino et al. (2006), Rohdin et al. (2007), Rettab and Brik (2008) and Bond and Perrett (2012) who argued that, companies adopt energy management measures stand a greater chance of enhancing their long-term competitiveness and productivity. This perspective can be considered as an incentives for the construction organizations to invest in and implement energy management technologies and approaches which include a collective efforts towards the efficient and wise utilization of all energy resources during onsite construction.

Besides that, the respondents agreed that *"There is energy efficiency gap in local construction industry"AEM4*, is the second known energy management awareness feature with (MS=3.89, SD= 0.89 and p-value=0.00) and lies into high agreement indicator category. The respondents highly agreed that energy issues are poorly managed in local construction industry and there is a divergence between the optimal levels of application of energy management and the levels actually practiced. This gap claimed to demonstrate the shortcomings of the local construction sector to efficient use of energy sources during project construction and the low application of energy management principles. This result confirmed the respondents' recognition of the importance of energy issues in construction and demonstrated their awareness that it should be managed to improve its utilization during construction process to close this gap. Wai et al. (2006) reported that bringing people's attention closer to the energy problems will help them to better understand about the energy issue and management. In the same line, the study conducted by Apeaning (2012) revealed that industrial firms in Ghana have a strong knowledge of the existence of an energy efficiency gap.

On the other hand, the results indicate that the respondents agreed that *"GHG emissions are the highest negative environmental impact associated with energy use during onsite construction" AEM3*, is the least known energy management awareness feature with (MS=2.70, SD=0.88 and p-value=0.00) and lies into average agreement indicator category. The average awareness about this issue indicated that the local contractors know that energy use in construction causes many environmental effects. However, the last position assigned to this feature indicated that, although local contractors know that energy use associated with several negative environmental impacts but they lower level of knowledge about the types and natures of these effects and emissions associated with the use of energy, which have a negative impact on the environmental. Accurately, this knowledge level about the nature of emissions associated with energy use can be attributed to the lack of interest from the local contracting companies about environmental matters during their activities. This result agreed with the conclusion of Enshassi (2000) who stated that there is a considerable lack of environmental public awareness in Gaza Strip about the interrelated nature of all human activities and their effects on the environment. In addition, the last position of this feature can be attributed to the fact that “Green House Gas Emissions” contribute to small portion of total environmental impacts of energy use in construction activities when compared with other environmental impacts such as pollution and dust, etc. In the same line with this results, the study conducted by WBCSD (2008) which indicated that building professionals recognized that sustainable buildings are important for the environment but underestimate the construction contribution to greenhouse gas levels, which is actually about 40%.

Indeed, GHG emissions associated with energy use in construction is new subject in the studies related to energy use impacts. Vesma (2012) recognized that minimizing carbon emissions is new added subject of energy management as well reducing the cost of energy used by an organization. Hong et al. (2015) reported that although construction phase in a building's life cycle is relatively short, the density of the carbon emissions in the construction phase is higher than other phases of the project life cycle. Al-Homoud (2000) reported that energy management is the first step towards reducing production of environmentally damaging products such as GHG emissions. The significance of this feature would correlate with Wai et al. (2006) assertion that the first step in the promotion of energy efficiency and renewable energy is information and education concerning energy environmental issue. Therefore, in order to achieve better awareness and application about energy management in construction industry, it is important to expose construction firms’ management and employees about the environmental impacts related to energy use during construction and other phases. Carbon Trust (2011) agreed with this result which concluded that energy management is the principal element of emissions management.

Furth more, the main key to control energy consumption and cost is by understanding “when” and “where” energy is consumed within facilities (Gorp, 2004; Abu Bakar et al., 2013). Meanwhile, the respondents have a moderate agreement about the criterion stated that

*"Onsite energy costs represent an important part of the project overall costs" AEM1,* with (MS=2.80, SD=0.61 and p-value=0.01) and lies into average agreement indicator category. The late position of this feature obtained because project energy expenses in local construction had low concerns from the contracting companies. This result can be attributed to the respondents' comparison between project energy expenses with other resources expenses in their projects. Hence, they consider it so small when considering other resources costs and has lower importance to be managed. This result clearly can be interpreted by Wai (2009) observation, that project energy awareness is the first step to achieve energy management awareness and then project energy sustainability can be emerged.

In summary, the previous results of the questionnaire survey initially concluded that local construction contractors have average level of awareness about energy issues and energy management. Besides that, they recognized more the benefits that construction firms would gain from implementing energy management. Local construction contractors know that energy use in construction negatively affect the surrounded environment. Otherwise, the provided statistics pinpointed that there is a lack of understanding of the nature and forms of these negative environmental impacts. While it is perhaps not surprising that improvement in competitive advantage gained as a result of applying energy management has a far greater focus amongst the respondents than the other energy management features, it is interesting to note that GHG emissions ranked in the lowest position, implying that economic advantages related to energy management were known to the respondents more than the environmental related issues. In close with these results, a questionnaire conducted among construction developers in Malaysia indicated that awareness of sustainable construction is rather limited (Abidin, 2009). Recently, a study conducted by AlSanad (2015) illustrated that, construction stakeholders awareness level of sustainable construction in Kuwait ranged from moderate to low.

## 4.3 Application level of energy management in local construction sector.

From the literature review, it becomes clear that energy management concept was beginning to settle in the construction industry. To understand how far this concept has penetrated the industry, the third part of the study questionnaire was focused on the local contractors, whether they have incorporate this concept within their current and past activities and management systems or not. The participating respondents were provided with a list of possible energy management requirements from which to define to what extent each of them has been implemented by their organization. Considering the application level of these requirements can be helpful to appreciate the range of energy management as a whole and how local contractors logically target different approaches of energy conservation process.

Seventeen representative energy management requirements were found to be significantly and substantially used in current practice to measure energy management application level in industrial firms, which were labeled as PEM1 to PEM17 in sequence. Table (4.3) lists analysis results of this section, including the mean score (MS), standard deviation (SD), t-test results, average index indicator and ranking order calculations on the level of application of each proposed requirement of energy management. The mean scores for the seventeen energy management requirements was used to represent a company's level of application of energy management; the higher this score, the higher the level of energy management application. The application level of each requirement was generated on the basis of the average index method, that requires comparing each requirement mean score (MS) with suggested mean score ranges to attain the application index ("very high for 4.50 ≤ MS ≤ 5.00", "high for 3.50 ≤ MS < 4.50", "average for 2.50 ≤ MS < 3.50", "low for 1.50 ≤ MS < 2.50" and " very low for 0.00 ≤ MS< 1.50"). In fact, Wai et al. (2011), Mohamad et al. (2012) and Memon et al. (2014) have used this method to complete their studies. Figure (4.2) provides graphical presentation of the application requirements mean scores.

One sample t-test was undertaken to determine whether the respondents considered the proposed requirements to be important to measure application level of energy management or not. From these results, it can deduced that, the respondents considered all the listed requirements significant in measuring the level of application of energy management in local construction sector because all of them have p-value less than the significance level 0.05 and all of them t-values were greater than the critical t-value (1.99). In addition, only one requirement (PEM1) has a positive t-value (+2.09) which indicated that this requirement mean score higher than the hypothesized value (3) as obtained in the table (MS=3.14). All the other requirements (16 from 17) have a negative t-value which yielded mean score values smaller than the hypothesized value (3).

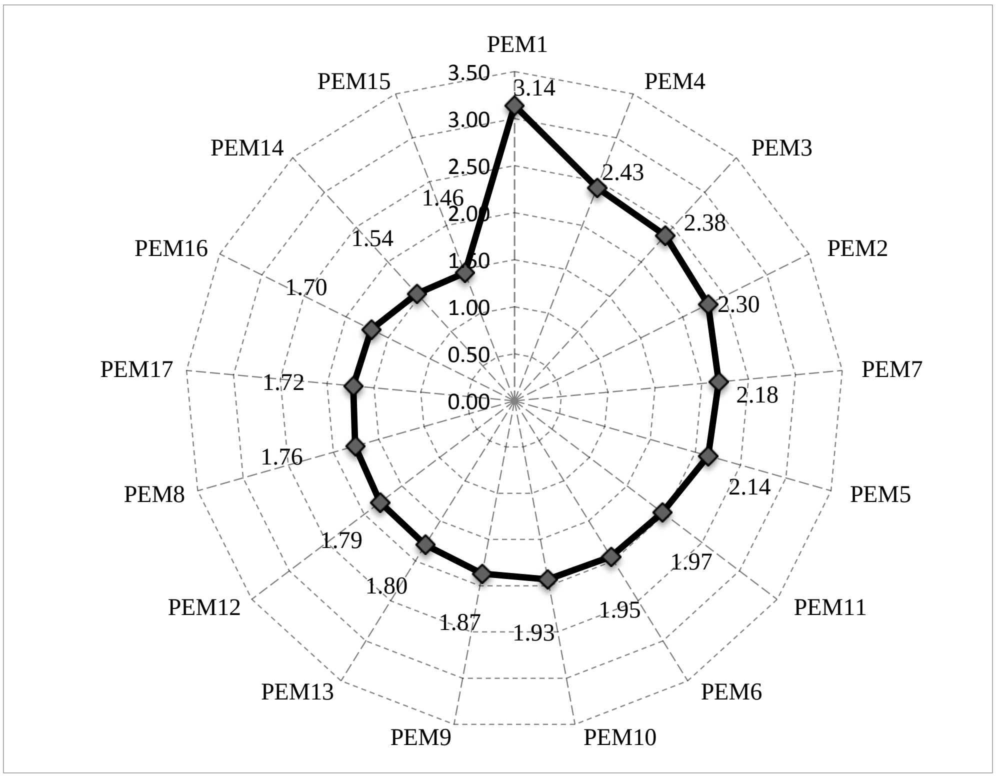


Figure (4.2): Mean scores of energy management application requirements *"AEM1 to AEM10"*

Table (4.3): Respondents level of application of energy management requirements.

| No. | Energy management application requirements | MS | SD | t-value | P-value (2-tailed) | Average Index Indicator | Rank |
|---|---|---|---|---|---|---|---|
| PEM1 | My company preparing an environmental management program for each project. | 3.14 | 0.60 | 2.09 | 0.02 | Average | 1 |
| PEM4 | My company conducting energy audit and accounting for its onsite works to record and report energy consumption and saving opportunities. | 2.43 | 0.91 | -5.40 | 0.00 | Low | 2 |
| PEM3 | My company providing a strategy to save onsite energy for each project. | 2.38 | 0.98 | -5.50 | 0.00 | Low | 3 |
| PEM2 | My company presenting onsite energy management as one component of its written policy. | 2.30 | 0.86 | -7.03 | 0.00 | Low | 4 |
| PEM7 | My company preparing an energy management plan for each project to save onsite energy . | 2.18 | 0.92 | -7.73 | 0.00 | Low | 5 |
| PEM5 | My company establishing an energy saving objectives and targets for all onsite works. | 2.14 | 0.92 | -8.11 | 0.00 | Low | 6 |
| PEM11 | My company regularly assessing the compliance and committing to all legal obligations and other regulatory requirements related to energy aspects for onsite works. | 1.97 | 0.86 | -10.36 | 0.00 | Low | 7 |
| PEM6 | My company identifying unique key performance indicators related to onsite energy issues. | 1.95 | 0.86 | -10.64 | 0.00 | Low | 8 |
| PEM10 | My company conducting regular assessment of its future energy needs. | 1.93 | 0.82 | -11.30 | 0.00 | Low | 9 |
| PEM9 | My company conducting periodic revision of significant historical data related to energy aspects for onsite works. | 1.87 | 0.81 | -12.24 | 0.00 | Low | 10 |
| PEM13 | My company providing the required experienced personnel, as well as technical and financial resources to save energy during on site construction. | 1.80 | 0.75 | -13.94 | 0.00 | Low | 11 |

Table (4.3): Respondents level of application of energy management requirements "continued"

| No. | Energy management application requirements | MS | SD | t-value | P-value (2-tailed) | Average Index Indicator | Rank |
|---|---|---|---|---|---|---|---|
| PEM12 | My company hiring a specialized committee or person responsible for all energy issues during onsite works. | 1.79 | 0.75 | -14.00 | 0.00 | Low | 12 |
| PEM8 | My company setting a monitoring system for energy use during onsite works. | 1.76 | 0.75 | -14.45 | 0.00 | Low | 13 |
| PEM17 | My company providing awareness programs and tools to save energy during onsite works. | 1.72 | 0.69 | -16.24 | 0.00 | Low | 14 |
| PEM16 | My company providing specialized energy management training programs for its employees. | 1.70 | 0.65 | -17.37 | 0.00 | Low | 15 |
| PEM14 | My company introducing incentives for energy saving during onsite construction works. | 1.54 | 0.62 | -20.52 | 0.00 | Low | 16 |
| PEM15 | My company creating and using energy manual to save energy during onsite works. | 1.46 | 0.55 | -24.30 | 0.00 | Very low | 17 |
| | Overall application requirements | 2.01 | 0.52 | -16.55 | 0.00 | Low | |

- *MS: Mean Score* *SD: Standard Deviation*
- *Critical t-value (two-tailed): at degree of freedom (df) = [N-1] = [76-1] = 75 and significance level 0.05 equals "1.99"*
- *The hypothesized population mean is the critical rating at 3.*

As observed in the Table (4.3), the mean score (MS) value of the application of energy management requirements ranged from 1.46 to 3.14 with overall mean score of 2.01. There are fifteen out of the total seventeen application requirements with low application degree according to the adopted average index indicator and one of the remaining two requirements has average degree of application with highest application level of the listed requirements, and the other requirement has a very low degree of application with least application level. These results demonstrated that, the respondents have very low to average degree of application of the energy management requirements included in the study. In addition, the average mean score (MS) of the listed requirements equals ($1.50 \leq$ "Overall MS =2.01" $<$ 2.50) which indicated that, the overall application level corresponds with low application indicator category. It is evident from these results that, energy management very limited applied by the majority of the local construction contractors in their construction activities.

The reasons for the current level of implementation can be clustered under several headings. It is clear that the respondents have a moderate level of awareness about energy management benefits while they are lack the knowledge about the techniques and standards to implement energy management concept. In fact, this issue was not in their top list which make general lack of urgency on this issue. Also, this issue lacked of publicity which could speed up contractors management interest on the matter. Besides that, energy management application will pose an unacceptable cost to the local contractors which will make them concerned about adopting this concept in their activities. From other side, energy issues haven't been the predominant considerations for the owners\clients in the preparation of conditions and specifications for conventional local construction projects. Many other constraints impeding energy management adoption during project construction as will be discussed latter in this study such as lack of support from company management, lack of the company staff awareness on the importance of energy management in construction and so on. This result conforms with the finding of the study carried out by Kostka et al. (2013) who surveyed 480 SMEs in Zhejiang Province of China and observed that only a minority of them actively perform energy saving practices at a significant level. Also, this result is similar to the conclusion of Ates and Durakbasa (2012) study which pointed out that, only 22% of the surveyed industrial companies actually practice energy management in Turkey. In addition, Christoffersen et al. (2006**)** concluded that, between 3% and 14% of the industrial Danish firms practice energy management.

It is clearly shown that, the respondents ranked moderately and in first position the requirements stated that *"My company preparing an environmental management program for each project" PEM1* with mean score (MS=3.14, SD=0.60 and p-value=0.00) and it lies into average application indicator category. From the awareness section results, it is clear that, the respondents moderately aware that energy use in construction negatively affects the environment. This again suggests that environmental issues are moderately considered in practice as a result of the average to high environmental awareness levels claimed by the respondents. In fact, preparing environmental management plans and programs in local construction sector emerged as a result of the contractual requirements, as the participated firms in this study have a high classification which mean that they deal with large projects that require special conditions and specifications and issued mainly by large donors\owners in which environmental issues are one of the main requirements of these project contracts. In consistent with this result, Majdalani et al. (2006) observed that, Lebanese contracting firms are not enforcing much good environmental practices as reflected in the relatively low importance indexes. Also the study conducted by Abd Elkhalek et al. (2015) revealed that 40.6 per cent of Egyptian contractors didn't have any stated environmental management policy, objective and procedure which indicated that environmental management system implementation and adoption in the Egyptian construction industry is very poor

The study respondents rated the requirement *"My company conducting energy audit and accounting for its onsite works to record and report energy consumption and saving opportunities" PEM4*, in the second position of energy management requirement applied in the respondents organizations with (MS=2.43, SD=0.91 and p-value=0.00) and lies into low application category. Although its low application level, this requirement was located in advanced application position among the other energy management requirements because local contractors can implement energy accounting and auditing without additional financial costs. In addition, energy consumption control and accounting in local construction sector have been performed in unstructured and informal forms for the purposes of estimating energy needs to operate required equipment or to realize energy share in project cost only. Generally, the outcome of this energy audit are information related to the time and amount about the required energy for the project (Kannan and Boie, 2003). This result is supported by Thollander et al. (2013), who reported that after an energy audit a company starts to adopt other requirements and measures leading to lower energy use. Otherwise, this low application level of energy audit can be attributed to the low awareness about energy management strategies and techniques in construction to conduct systematic audit. This observation associated with Choong et al. (2012) results that planning of energy management begins when an organization realizes that energy is a resource that is needed to be managed.

The requirement that was ranked in the last position of the proposed requirements was *"My company creating and using energy manual to save energy during onsite works" PEM15* with (MS=1.46, SD=0.55 and p-value=0.00) and lies into very low application category. Eventually, this very low application approximately means that energy management manual has't used in local construction sector and only some guidance may be found informally from experience only. To some extent, this can be attributed to the limited experience and interest of the local contractors top management about energy management technologies, strategies and approaches. In the same line, this result revealed that none of the studied firms had a specialize personnel assigned to manage energy, as such most of the energy issues were handled by the technical employees and middle managers. UNIDO (2007) study can interpret the previous result gained, that preparing energy manual generally based on previous, undertaken and documented energy saving practices and policies in the firm. On the other hand, standards, regulations or practices related to energy management which are required to develop energy manual are unavailable in the case of the local construction sector. Therefore, it is not surprise to see this requirement in the least position among energy management requirement.

To conclude, it can be noted that to address the level of energy management application in local construction sector, a systematic examination was conducted of the local contracting organizations which reflected the application level of energy management in their activities. It is worth noting that, with the help of the 17 energy management requirements introduced above, it has been found out that the mean scores for the practice of energy management in local construction sector were relatively low "poor application", indicating that the contracting companies in Gaza Strip were not strictly applying energy management in their projects. Otherwise, some contracting organizations in Gaza Strip have already started the application of some energy management activities on small scale in one way or the other but not necessarily in a well-structured framework. In many other organizations, on the other hand, energy management have not been considered seriously. Therefore, it can be found out that energy management haven't applied in professional, systematic and planned approaches in local construction sector. This application fashion of energy management can be used to interpret the existence of an energy management gap in local construction sector.

Environmental related issues are the most practiced activities and requirements which emerged as a result of the contractual arrangements and procedures only. Indeed, these environmental programs didn’t specifically related to energy issues and impacts but it often related to several environmental impacts related to the construction activities such as dust and exhaust, etc. Similar observation were reported by Apeaning (2012) who revealed that majority of the surveyed industries in Ghana had no standardized energy policy and management system as they consider the use of energy is not an environmental hotspot.

## 4.4 Relationship between energy management awareness and application levels.

In general, the level of awareness and the level of implementation and practice of energy management are closely linked (Abidin,2009). To validate this conclusion, Pearson's correlation coefficient was used to measure the strength and direction of the relationship between awareness and application levels of energy management in construction industry. According to the results shown in Table (4.4), it can be found that there is strong statistically significant positive correlation between “energy management awareness features” and “ energy management application requirements” with (r =+0.76, p-value = 0.00). The significance value is less than 0.05, and thus the relationship is statistically significant at p-value $\leq 0.05$. The closer ($r$) to +1, the stronger the positive correlation, while the closer ($r$) to -1, the stronger the negative correlation. This means, when one energy awareness increases, its application level increases, and vice visa.

Table (4.4): Correlation coefficient between local contractors awareness level of energy management and its degree of practice

| Field | Statistic | Local contractors level of awareness/knowledge of energy management. |
|---|---|---|
| Local contractors degree of practice of energy saving and management in the construction projects | Pearson correlation ($r$) | $0.76^{**}$ |
| | $P$-value (2-tailed) | 0.00 |
| | Sample size ($N$) | 76 |

***. Correlation is significant at the 0.01 level (2-tailed).*

As mentioned from the previous results, it is not surprising to find this strong relationship between awareness level about energy issues and the local contractors level of application of this issue. It is clear that the effort put into action and adoption towards the concept of energy management depends on the awareness, knowledge and understanding of the energy management benefits, impacts, measures, technologies, standards and techniques, which will make the contractors more committed to apply energy management in their activities. In addition, applying energy management in the firm will expand their awareness level about any new techniques and standard related to this issue. This result suggests that future energy management adoption can be improved upon the situation by providing firms with relevant knowledge about energy management and efficiency issues. WEC (2004) study agreed with this result, which showed that increased awareness can open range of possibilities for the management decisions to apply energy saving in their organizations.

Management is incompatible with the their degree of awareness about this issue. Thus, it can be deduced that, although local construction companies have amoderate knowledge of energy management as described in awareness section, they have no formal approaches to adopt it and most of them do not show any intention to adopt it in the near future. This result is supported by the finding obtained by Yaseen (2008) who concluded that a big gab in awareness and application exists at the management level in Palestinian industry. The reason for this notable gap between awareness and application level will be made clear by the drivers and barrier analysis in the following sections.

Existence of some barriers or absence of several motivates to save energy in construction sector are the main reasons for energy management gap in local construction sector. Besides that, this study respondents perception about the benefits of the energy management were based on intuition rather than empirical data or experience as they looking to it as one management system that can improve the usage of one resources of overall project resources. So that, the construction industry must intensify the efforts oriented to improve the use and management of such important resource. In the same line with this result , World Business Council for Sustainable Development WBCSD (2008), conducted a research in eight countries around the world between 2006 and 2007 to gauge the perceptions of building professional about sustainability and energy efficiency, which revealed that awareness level of environmental and energy issues is relatively acceptable in building and construction sector. But this level drop sharply on questions about involvement in environmental and energy management activities.

The previous discussions provided very useful information in respect of energy management among construction contractors in Gaza strip. Three important conclusions can be drawn from the analysis as follows :

1. Local contractors have a moderate knowledge about energy management. As specified in the first section, they were acknowledged the importance of energy management and its benefits in improving the company performance and reduction in costs attained. However, local contractors described a bad knowledge level about the nature of negative effects associated with energy use in construction, such as, GHG emissions nature, its effects and contents or how it is generated.
2. Energy management didn't applied in local construction sector whereas some issue related to its concepts little applied with informal system as a result of the contractual requirements.
3. The findings have disclosed that although local contractors feel the needs to conserve energy in the construction process, however, they may not want to contribute in the energy saving activities. It seems that there is a gap between attitudes and the behaviors about energy management in local construction sector.

### 4.5 Major drivers enhancing local contractors to adopt energy management during project construction.

This part aims to accomplish the third objective of this study by investigating the factors influence the implementation of energy management in local construction contracting companies. The study of these factors (drivers) in relation to energy management adoption gives good insight to policy makers on how to boost implementation of energy efficient measures and practices (Apeaning, 2012). For that, in the fourth section of the study questionnaire, 26 common drivers for adopting energy management were identified. These factors have a very important influence on implementing energy-related improvements in several industries especially, construction industry. These drivers were subjected to different analysis processes and tests (descriptive, t-tests and factor analysis) in order to formulate the basic conclusions related to the third objective of this study. The following sections provide detailed descriptions of the analysis results related to these drivers analysis results.

#### 4.5.1 Relative Importance Indexes (RIIs) and ranking of the drivers for energy management adoption.

The respondents were asked about the main reasons that may enhance them or may drive them to be involved in energy management in the future. Table (4.5) stipulates the mean values (MS), standard deviation (SD), t-value, p-value, relative importance index (RII) and ranking for each driver as perceived by the participating respondents. RIIs values of all drivers were presented in Figure (4.3) to provide a clearer picture of the consensus reached by the respondents. Furthermore, the one-sample t-test was used to establish the importance of each item in driving local contractors to adopt energy management, so that, energy consumption and its costs during construction process can be reduced. Relative importance index (RII) where used to rank each driver according to its degree of effectiveness in driving the respondents to adopt energy management.

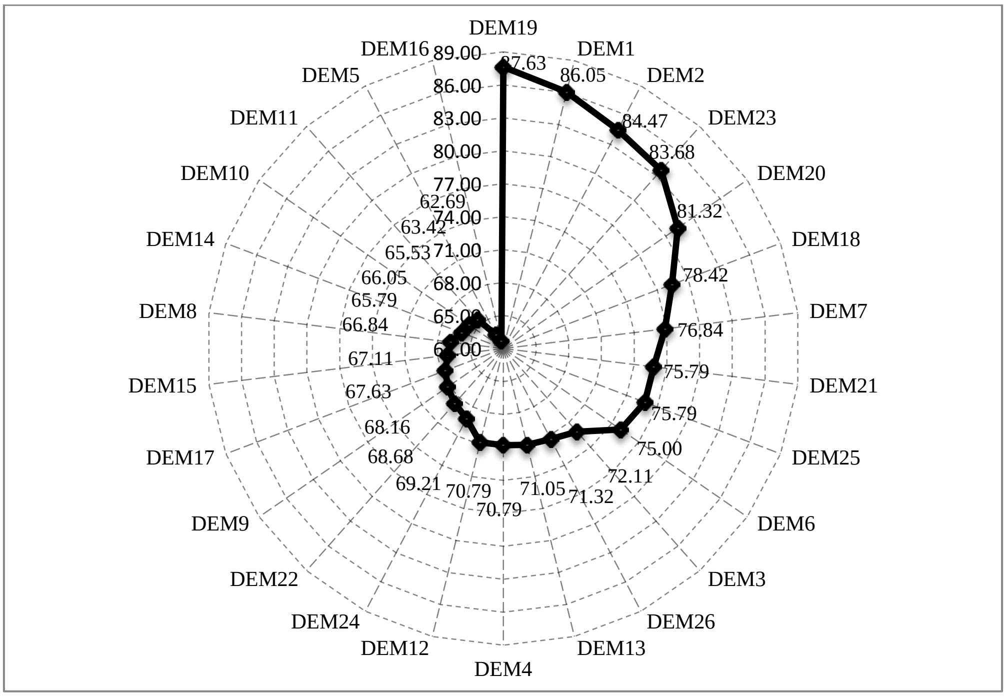


Figure (4.3): RII of energy management adoption drivers
*" DEM1 to DEM26"*

Table (4.5): Analysis results of energy management adoption drivers

| No. | Energy management adoption driver | MS | RII | SD | t-value | P-value (2-tailed) | Rank |
|---|---|---|---|---|---|---|---|
| DEM19 | Cost saving gained from adopted energy management strategies. | 4.38 | 87.63 | 0.73 | 16.51 | 0.00 | 1 |
| DEM1 | Existence of government regulations related to energy consumption and saving issues for construction industry. | 4.30 | 86.05 | 0.67 | 16.86 | 0.00 | 2 |
| DEM2 | Strength and enforcement of the governmental requirements for onsite construction energy saving. | 4.22 | 84.47 | 0.64 | 16.54 | 0.00 | 3 |
| DEM23 | Improvement of the company competitive advantage and reputation as a result of adopting energy management in its projects. | 4.18 | 83.68 | 0.74 | 13.89 | 0.00 | 4 |
| DEM20 | High energy amounts and costs required during onsite works in the project. | 4.07 | 81.32 | 0.79 | 11.78 | 0.00 | 5 |
| DEM18 | Rising energy prices in local market. | 3.92 | 78.42 | 0.83 | 9.69 | 0.00 | 6 |
| DEM7 | Construction employees awareness of onsite energy use and problems. | 3.84 | 76.84 | 0.75 | 9.80 | 0.00 | 7 |
| DEM21 | Decrease price levels of energy saving technology for construction industry. | 3.79 | 75.79 | 0.81 | 8.55 | 0.00 | 8 |
| DEM25 | Availability of building code requirements for energy saving and management. | 3.79 | 75.79 | 0.70 | 9.85 | 0.00 | 9 |
| DEM6 | Increased education level of the contractor employees. | 3.75 | 75.00 | 0.83 | 7.83 | 0.00 | 10 |
| DEM3 | Contractor energy performance is one criteria of the company rating in local construction sector . | 3.61 | 72.11 | 0.73 | 7.21 | 0.00 | 11 |
| DEM26 | Availability of new energy saving solutions, products and tools in local market. | 3.57 | 71.32 | 0.77 | 6.39 | 0.00 | 12 |
| DEM13 | Contractor willingness to satisfy client/donor requirements regarding energy issues. | 3.55 | 71.05 | 0.72 | 6.70 | 0.00 | 13 |
| DEM4 | Imposed governmental tax for energy use and emissions on construction companies. | 3.54 | 70.79 | 0.68 | 6.90 | 0.00 | 14 |
| DEM12 | Top management support to sustainable, energy management and saving activities. | 3.54 | 70.79 | 0.72 | 6.53 | 0.00 | 15 |
| DEM24 | Improved onsite working conditions. | 3.46 | 69.21 | 0.70 | 5.73 | 0.00 | 16 |

Table (4.5): Analysis results of energy management adoption drivers "Continued"

| No. | Energy management adoption driver | MS | RII | SD | t-value | P-value (2-tailed) | Rank |
|---|---|---|---|---|---|---|---|
| DEM22 | Availability of different energy types, sources and alternatives in local market. | 3.43 | 68.68 | 0.88 | 4.28 | 0.00 | 17 |
| DEM9 | Availability of experts for energy efficiency in construction industry | 3.41 | 68.16 | 0.79 | 4.52 | 0.00 | 18 |
| DEM17 | Availability of the financial support for energy saving strategies/plans and investments. | 3.38 | 67.63 | 0.86 | 3.85 | 0.00 | 19 |
| DEM15 | Availability of information on successfully implemented energy management practices in construction. | 3.36 | 67.11 | 0.78 | 3.98 | 0.00 | 20 |
| DEM8 | Existence of sustainability policy within the contractor organization. | 3.34 | 66.84 | 0.70 | 4.24 | 0.00 | 21 |
| DEM14 | Availability and frequency of internal training on energy management | 3.30 | 66.05 | 0.67 | 3.92 | 0.00 | 22 |
| DEM10 | Adoption of energy performance contracts (EPC) in local construction market. | 3.29 | 65.79 | 0.65 | 3.89 | 0.00 | 23 |
| DEM11 | Availability of long term energy management strategies within the construction companies. | 3.28 | 65.53 | 0.69 | 3.52 | 0.00 | 24 |
| DEM5 | Contract conditions containing specific environmental requirements | 3.17 | 63.42 | 0.68 | 2.19 | 0.03 | 25 |
| DEM16 | Government support for researchers in energy management in construction industry. | 3.13 | 62.69 | 0.58 | 2.17 | 0.03 | 26 |
| | Overall energy management adoption driver | 3.64 | 72.8 | 0.30 | 18.88 | 0.00 | --- |

- *MS: Mean Score* *RII: Relative Importance Index* *SD: Standard Deviation*
- *Critical t-value (two-tailed): at degree of freedom (df) = [N-1] = [76-1] = 75 and significance level 0.05 equals "1.99"* - *The hypothesized population mean is the critical rating at 3.*
-

Based on the t-test results shown in Table (4.5), all items listed in the questionnaire with a significance level less than 0.05, which indicated that there is clear agreement between the respondents about the effectiveness of these drivers in improving the adoption of energy management in local construction sector. All listed drivers have t-value larger than the critical t-value (1.99), which verified the significance of all proposed drivers in encouraging local contractors to adopt energy management in construction projects. Additionally, t-values for all drivers in the table are positive , which indicated that all drivers mean values are larger than the hypothesized mean (3). From Table (4.5), it can be shown that the mean of all drivers is larger than 3, which reveals that on overall, any present actions to push energy management in local construction contracting companies may have significant impact to the industry as driving forces which should stimulate energy management. Furthermore, the fact that the standard deviations for all drivers less than 1.0 indicates that there is little variability in the data and consistency in agreement among the respondents (Wai et al. 2011).

The ability to make cost savings is one of the key factors driving the consideration of energy management issues in different industries (Christoffersen et al., 2006). In line with this conclusion, Table (4.5) shows that the respondents considered the driver "*Cost saving gained from adopted energy management strategies*" *DEM19*, as the most effective factor that may drive the local contractors to adopt energy management in their construction projects, with (MS= 4.38, RII=87.63%, SD=0.73 and p-value= 0.00). The significance of this driver is in accordance with the previous studies conducted by De Groot et al. (2001), Christoffersen et al. (2006), UNEP (2006), Stefan (2008), Apeaning (2012) and Apeaning and Thollander (2013), which ranked "*Cost reductions resulting from lowered energy use*" as the most important driver to adopt energy management and energy efficiency in industry. As an evidence of this result, Chuanzhong and Yingji (2011) indicated that most business companies can reduce their energy costs about 10–25% by adopting resources and energy management best strategies. Russell (2005) contended that many efficiency proponents believe that top managers will accept any energy improvement proposals if these proposals proved the cost savings or payback from adopting energy management in the company activities. In contrast with this result, the study conducted by ClimateWorks-Australia (2013) on 47 large industrial companies in Australia reported that, *"Steep energy price rises over the last five years"* was the main driver for more energy efficiency improvements in these companies.

Construction project supply chain of developers, suppliers, manufacturers, design and construction teams are under increasing pressure from clients to minimize total project cost (Akadiri et al., 2012). Considering that most construction projects performed in Gaza Strip are awarded based on the lowest tender price which causes the project cost related issues to be very sensitive to all stakeholders in the industry. From this result, it is clear that although there is uncertainty about the value and standards for energy management adoption at the present, local contractors optimism was clearly identified. However, the level of uptake and investment in energy management in construction would be accelerated if evidence for the financial benefits for energy management were proven.

The respondents also ranked "*Existence of government regulations related to energy consumption and saving issues for construction industry*" *DEM1* with (MS= 4.30, RII= 86.05%, SD=0.67 and p-value= 0.00) in the second position of the proposed drivers, followed by "*Strength and enforcement of the governmental requirements for onsite construction energy saving*" *DEM2,* with (MS= 4.22 , RII= 84.47%, SD=0.64 and p-value= 0.00), as third effective drivers. Both of these drivers are regulation related, which indicates that, Palestinian construction sector is primarily driven by regulations on environmental issues, even though there are no specific stringent laws or standards with regard to energy use and management in industrial sectors by the Palestinian government. This result agrees with the outcomes of the previous work prepared by Apeaning (2012), which ranked *"Energy efficiency requirements by Ghanaian government"* as the third most important driver, even though there are no any regulations or measures with regard to energy use in industrial outfit by the Ghanaian government. In the same line, this finding is reinforced by Stefan (2008) study results, which ranked the existence of legal regulations or foreseeable political developments in the second most important motivation for energy management application. The research findings on building industry conducted by WBCSD (2008) demonstrated that, many building industry professionals will adopt new practices if they are required by regulation. Samari et al. (2013) argued that, legislations or policies is the best driver that can be tailored towards sustainable construction which enforcing the construction firms to practice sustainability measures in their projects. Recently, AlSanad (2015) study respondents indicated that the vast majority of construction stakeholders, 88.1% either agreed or strongly agreed that government intervention is necessary to ensure the adoption of green construction practices in Kuwait.

On other line, existence of governmental regulations is inadequate to improve energy management adoption, but it requires reinforcement to be fully applied. The results of this study demonstrated the logical sequence obtained for these two drivers where that enforcement for the application of energy related regulations requires the existence of a framework for these regulations and related standards previously. Reinforcing the implementation of relevant laws and regulations in managing and supervising the work in energy field will ensure sustainable energy development (Jiang, 2008). UNEP-SBCI (2009) recognized that existing environmental regulatory policies only will make an impact on reducing greenhouse gas emissions if they are enforced. This result is supported by the findings obtained by Rettab and Brik (2008), in which the compliance with regulations was ranked as the second primary driver to encourage industrial companies in Dubai to adopt green supply chain. Roberts (1997) found that some companies have embarked on environmental management programs in advance of legislation, they do so mainly because of the threat of legal action. In addition, tough regulations can force organizations into innovating to produce less polluting or more efficient products with high value (Akinbami and Lawal, 2009).

Since energy management application primarily driven by regulations, it reflects the concerns of the government. Legislative body has an important role to play in preparing the necessary legal infrastructure to protect the interest of the construction parties and to prompt a wider adaptation of sustainable construction practices; this can only be achieved if the government takes a leadership role in this regard (Majdalani et al., 2006). Different governments worldwide share a major concerns for environmental issues, and are factoring these concerns into their regulations and decisions (Sustainability Victoria, 2007). Whilst government bodies and international agencies in Palestine have begun to pay attention to aspects of sustainable construction, it hasn’t occurred due to internal convictions, but rather due to international standards and funders requirements (Yaseen, 2008). Jarnehammar et al. (2008) attributed the reason for absence of specific energy laws to the political processes and priorities which will together determine the willingness of governments to promote energy improvement investment. However, this fact spells out the potential importance and strong influence of government authorities in the implementation of energy management in local industries.

Based on the aforementioned discussion, it can be deduced that the issue of local regulations is of a critical issue as it can play an important role in persuading people and organizations to implement energy management practices and more energy efficient activities. Clearly, current environmental and energy related regulations in all sectors are not available in Gaza Strip. Accordingly, a bigger role should be played by the legislative body in collaboration with all stakeholders, mainly the government, in order to ensure that the legal infrastructure is well designed and prepared for such an important transformation in the construction sector. In addition, construction organizations need to devise appropriate measures to respond to governmental regulations related to any environmental subject. These measures include compliance with legal frameworks, technological innovation and managerial processes improvements (Baloi, 2003).

*"Contract conditions containing specific environmental requirements" DEM5* was ranked in position 25 of the suggested 26 drivers which is the position before the last ranked driver immediately, with (MS= 3.17 , RII= 63.42%, 0.68 and p-value= 0.03). Although its' late position, it is clear that the respondents agreed about the important of this factor in driving energy management adoption as its MS > 3, RII > 60% and its p-value < 0.05. Majdalani et al. (2006) study findings conducted in Lebanon agreed about this factor importance, which concluded that fostering environmentally friendly construction practices and the inclusion of special conditions in tender documents were considered as important factors in sustainable development.

Otherwise, the late position of this driver obtained as a result of lack of interest in local contract requirements and conditions for energy use and saving. Environmental issues haven't been the predominant considerations for the owners\clients in the preparation of conditions and specifications for conventional local construction projects. Akadiri et al. (2012) stated that for many owners\clients, cost is their primary and often only concern. Whereas, if there any conditions related to energy management, it is not widely known to many construction practitioners. The existing multiplicity of agencies working to their own conditions of contract, and the differing forms in which contracts are prepared, adds to the confusion in implementing energy management requirements. Generally, construction documents and agreements haven't identified the contractor's environmental responsibilities and the scope of the work related to energy management. This finding can be clarified by the early outcome of the research by Shari and Soebarto (2012), which proposed two contributing factors to the lack of contract conditions for specific environmental requirements, the first factor is the lack of education or awareness about the requirements and specifications of sustainability and energy management in construction; and the second factor is the perception of energy management practices that will increase costs and reduce profits.

According to the previous discussion, in order for the construction industry to change its technology, procedures or investment programs to achieve improved application of energy management practices, it will need to formulate special conditions and specifications to control the industry toward efficient energy construction. Baloi (2003) observed that the site managers and the supervisors were assigned the main responsibility for environmental and energy management during construction process. This required the establishment of a formal structure in the contract formulation to implement the necessary supervision and control measures to ensure effective energy management.

*"Government support for researchers in energy management in construction industry" DEM16* was ranked in last position of the listed 26 drivers with (MS= 3.13, RII= 62.69%, SD=0.58 and p-value= 0.03). Although its' last position, the respondents agreed that governmental support for researches is important for driving the implementation of energy management in local construction contracting firms. Many reasons established the importance of governmental support for the scientific researches which can contribute in understanding and solving problems. It is well known that scientific researches can suggest new and more appropriate construction techniques and materials that might optimize resources and minimize energy use and cost. This driver importance conforms with the finding of the study carried out by Hwang and Tan (2012) in which, the respondents felt that subsidy from government for research and development of green building systems and management could essentially provide concrete evidence of how beneficial they are to humans, society as well as the economy. UNIDO (2011) explained that government's funding to research and development (R&D) and its' support to industrial sectors research will encouraging the adoption and diffusion of best available technologies and providing demonstration examples. In contrast with this result, Majdalani et al. (2006) concluded that support and initiatives for research and development (R&D) and continuous education approximately of no importance to all construction industry parties in Lebanon to increase the sustainable development. In contrast with the last rank identified in this study for the governmental support for research, AlSanad (2015) ranked the government subsidies for the educational programs and research and development of green construction to be the most important factor in order to promote and expedite efforts towards green and sustainable projects in Kuwait.

However, many reasons can interpret the last position given to this driver by the respondents. Accurately, at present, there is no effective governmental support in Gaza Strip to encourage researchers to perform different researches especially which are related to sustainable construction. This limited support occurred because local government in Palestine doesn't focus on environmental issues generally, and on industrial energy management and efficiency particularly. Although vital, Palestinian government generally haven't funding mechanisms for sustainability and energy improvement researches. Hence, the low application level of energy management has made the local government disregard providing support for researches related to this subject. Besides that, the researches may not yield any benefits for the industry as a result of this low practical use for energy management in construction industry. Also, it is clear that local educational/training institutions don't have the capacity relevant to energy management practices. In the same line, significant number of managers and employees of the local construction contracting companies haven't educated, which lower the government and the industry parties concerns to scientific researches and developments. Poor communication between researchers, educational organizations and government has made lower the government interest in research support and implementation. Plessis (2002) explained the importance of the coordination between construction sector with government, universities and other private sectors and related industries and institutions to provide the required financial support for sustainability and energy management researches. Actually, as one of the developing countries, Palestine will continue to rely on foreign researches and technologies because it lakes budget to support local researchers.

From the previous results, it is clear that the respondents believed that local government currently doesn't support innovative and constructive ideas and researches related to energy management and efficiency in construction sector. As a result of its dependence on foreign aids, Palestinian authority doesn't able to guarantee the necessary financial resources to support the research and the educational activities for the production and marketing of new materials and technologies that can help in increased adoption of sustainability and energy developments in local construction industry. Even if exist, many researches were conducted often too theoretical or unrealistic for the local needs and capabilities.

### 4.5.2 Factor analysis of the drivers to adopt energy management in construction sector.

In the second stage of data analysis process, factor analysis was employed to reduce a large number of variables (drivers) to a smaller set of underlying factors that summarize the essential information contained in the variables (drivers). Using SPSS 22, Principle Component Analysis (PCA) with Varimax rotation were performed to set up which items could capture the aspects of same dimension of the 26 energy management drivers and examine the underlying structure or structure of interrelationships among the drivers. In order to perform the factor analysis for used items, all the appropriate checks and procedures were fulfilled, as mentioned previously in chapter 3 (Research methodology). Three main phases were proceeded to accomplish factor analysis, as follows:

- **<u>First phase</u>: Preliminary analysis;**
- **<u>Second phase</u>: Factors extraction;**
- **<u>Third phase:</u> Factors naming and interpretation.**

***<u>First phase of factor analysis for energy management adoption drivers: Preliminary analysis.</u>***

Prior to the extraction of the factors, there are some investigations and tests must be conducted to examine the adequacy of the sample and the suitability of the drivers data obtained from questionnaire for factor analysis. This phase included different tests on the data to validate the appropriateness to proceed to the following process in factor analysis, as follows:

**1. Type of the study data (variables).**

It can be seen that all drivers (variables) studied in the questionnaire are subjective which mean that they were subjected to a perceptive opinion of the respondents. This indicated that these variables can be grouped under some constructs based on the responses of the respondents about it (Rehbinder, 2011). In addition, Yong and Pearce (2013) supposed that ordinal level of measurement with Likerts scale rationalize the appropriateness of these data for factor analysis. In this study, ordinal level of measurement with 5-points Likert scale was used to attain required results about the 26 driving forces for energy management in local construction sector. Hence, on the basis of the previous requirement, the data obtained for the 26 drivers in this study can be considered suitable for factor analysis.

2. **Distribution of the data**

Referring to the mentioned assumptions of the Central Limit Theorem. The sample size of the study was 76 respondents which is larger than 30. Hence, as proposed by Hair et al. (2010), the collected data of the questionnaire can be assumed to follow normal distribution. Accordingly, the normal distribution requirement for factor analysis application has been satisfied according to Field (2009) recommendation.

3. **Sample size**

Sample size of the study is an important requirement to apply factor analysis. The reliability and stability of the factor analysis results depend largely on sample size. As described previously , and from different guiding rules related to sample size requirements, the sample size in this research is 76 participants which is more than 50 and considered adequate as proposed by de Winter et al. (2009) and Sapnas and Zeller (2002). From another line, this part 26 variables (drivers), which means that the analysis has 76/26= 2.92 respondents per variable which is less than 5. This result revealed that the sample size is limited compared to the number of variables (drivers) (Tabachnick and Fidell, 2007; Hair et al., 2010). It was however not possible to collect more data or respondents because of time restrictions for this study, and the analysis had to continue with a sample size of 76 as discussed above .

4. **Data reliability test.**

To decide the reliability (internal consistency) of the 26 items, Table (4.8) showed that, Cronbach coefficient alpha equals 0.79, which considered acceptable (> 0.7) as recommended by Pallant (2005). This result revealed that, the initial data obtained from the participated sample about the 26 drivers were appropriate for factor analysis. In addition, as shown in Table (4.8), the reliability coefficient for the final solution of factor analysis which involved 19 drivers only, was 0.75. Reliability validation indicated the that the respondents ascertained the importance of the variables included in this study in driving the local contractors to adopt energy management.

5. **Factorability of the correlation matrix.**

One of the most important checks before a factor analysis can be conducted is generating the correlation matrix and checking whether the variables do not correlate too highly or too lowly with other variables (Field, 2009). The correlation between each pair of studied drivers were generated. Based on the visual inspection of the correlation matrix shown in Table (4.6) below. From this matrix for the 26 drivers (variables), it can be seen that each driver of them correlated with several other variables with correlation coefficients greater than 0.30. In the same time it can be seen from this table that, none of the correlation coefficients has a value greater than 0.9. For example, when inspecting the matrix presented in Table (4.6), it can be shown that the driver DEM1 has some correlation with other 6 drivers which were DEM2, *DEM3*, *DEM5*, *DEM10*, *DEM12*, *DEM16* and *DEM25* with a correlation coefficients equal to 0.58, 0.41, 0.47, 0.59, 0.43 and 0.42, respectively. In addition, this driver (*DEM1*) was not correlated with other variables in the group or correlated by very low correlation coefficients. Such as, its correlation with the drivers *DEM6*, *DEM11*, *DEM12*, *DEM14*, *DEM26* and etc., with correlation coefficient equals to 0.02, 0.07, 0.04, 0.00, 0.00, respectively. Field (2009) argued that, the variables that correlate highly with a group of others but at the same time correlate poorly with the variables that are outside of that group are suitable for factor analysis (Field, 2009).

Therefore, these variables (drivers) can be considered suitable to be involved in factor analysis because all of its correlation coefficients have been lower than 0.9 and larger than 0.3 as specified be Tabachnick and Fidell (2007). In general, the values of the correlation coefficients for energy management drivers showed an adequate correlation amongst several variables as shown in Table (4.6) in bold line. This result provides an adequate basis for proceeding to the next check, the empirical examination of the adequacy for factor analysis.

6. **Items Correlation Matrix Adequacy *"Kaiser-Meyer-Olkin (KMO) Measure of Sampling Adequacy/Bartlett's Test of Sphericity"***

This check performed to examine the anti-image correlation matrix; the diagonals on that specific matrix should have an overall measure of sampling adequacy (MSA) of 0.50 or above (Hair et al., 2010). Individual variables with MSA values less than 0.5 should be considered for elimination from further analysis. Table (4.7) below provided the anti-image correlation matrix for the 26 drivers for energy management as obtained from SPSS program. Examination of the bolded values of each variable in the diagonal of this matrix in Table can help in justifying the appropriateness of the involved data for factor analysis. In general, major drivers (25 of 26 drivers) included in the first run of factor analysis had MSA values more than 0.5. Only one driver (variable) with MSA alue less than 0.5 which was the driver *"Top management support to sustainable, energy management and saving activities" DEM12,* with (MSA=0.48 <0.5). Therefore, this variable (*DEM12*) should be removed from the initial data before proceeding to other checks required and factor analysis were repeated for the remaining 25 drivers (variables) excluded this variable.

On other hand, the data set of 26 variables where subjected to Kaiser–Meyer–Olkin sampling adequacy test and Bartlett's test of sphericity. Kaiser-Meyer-Olkin (KMO) and Bartlett's test have been employed to assess the appropriateness of the factor analysis process. Kaiser Meyer Olkin (KMO) statistic compares the magnitude of observed correlation coefficients with the magnitude of partial correlation coefficient. However, significance of the correlation matrix is established using Bartlett's test of sphericity. In general, Hair et al. (2010) and Mane and Nagesha (2014) pinpointed that, the Bartlett's test of sphericity is significant when (p-value <0.05), and when the value of the KMO index is above 0.5, suggesting the data set is suitable for factor analysis. The results of these tests should be checked in each run of factor analysis.

The results for these tests obtained from the first run and the final run of factor analysis about energy management driver have been reported in Table (4.8). The value of the Kaiser–Meyer–Olkin (KMO) measure of sampling Adequacy in the first run was (KMO= 0.68) which is considered acceptable as its value larger than 0.5. However, KMO value for the final run (eighth run) was 0.71 which explained the suitability of the final solution of the remaining 19 energy management drivers. The last control before moving on to the principal component analysis was to control that the Bartlett's test of sphericity had a significance level less than 0.05 (Field, 2009). In the first run, Bartlett test of sphericity with (chi-square=

1099.87), and the associated significance level was (p-value =0.00 <0.05), which indicated that Bartlett's test is highly significant and the population correlation matrix is not an identity matrix, so that, the data were good enough for further analysis (Larose, 2006).

After all requirements of the previous check were verified, an initial capture of the factors can be conducted using the remaining 25 variables/items (after removing *DEM12*) of the drivers for energy management application in construction industry, using the principal component analysis approach with exploratory factor analysis through SPSS V.22. Factor solutions with Varimax rotation were computed.

### ***Second phase of factor analysis for energy management adoption drivers : Factors extraction***

The principal component analysis (PCA) with varimax rotation was applied to explore the variables that can be included in one factor (component). PCA method adopted to validate which constructs to be distinct as perceived by the respondents. The latent root criterion was used with eigenvalues equal to or greater than unity, in order to establish the number of extraction factors (Tabachnick and Fidell, 2007).In addition, Scree plot was used here to verify the number of the factors generated on the basis of latent root criterion. Varimax rotation minimizes the number of variables that have high loadings on any one given factor. In the first run, with all the 26 drivers included in study, PCA method yielded six factors (components) based on Kaiser's criterion of retaining eigenvalues greater than 1.0 (Field, 2009). The initial six-factors solution accounted for 67.63 percent of the total variance. The final four-factors solution emerged from the remaining 19 variables (drivers), accounted for 66.10 percent of the total variance explained by this solution. The following checks should be performed on the results obtained from the extracted solution.

1. **Communality values**

One important table of factor analysis results is communality values table. Communality explains the total amount an original variable shares with all other variables included in the analysis and is very useful in deciding which variables to finally extract in the varimax rotation and in determining the adequacy of the sample size (Field, 2009). Eventually, after the first run, it can be seen that major extracted communalities for the items from the model of 6 factors was higher than 0.50 ( 25 of 26 variables), as can be shown in Table (4.9). Only one variables had a communality value less than 0.5 which was:

- *"Availability of building code requirements for energy saving and management" DEM25*, with a communality value equals to 0.497.

Table (4.6): Correlation matrix for energy management adoption drivers

| | DEM1 | DEM2 | DEM3 | DEM4 | DEM5 | DEM6 | DEM7 | DEM8 | DEM9 | DEM10 | DEM11 | DEM12 | DEM13 | DEM14 | DEM15 | DEM16 | DEM17 | DEM18 | DEM19 | DEM20 | DEM21 | DEM22 | DEM23 | DEM24 | DEM25 | DEM26 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DEM1 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | |
| DEM2 | **0.58** | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | |
| DEM3 | **0.41** | **0.64** | 1.00 | | | | | | | | | | | | | | | | | | | | | | | |
| DEM4 | 0.16 | 0.15 | 0.14 | 1.00 | | | | | | | | | | | | | | | | | | | | | | |
| DEM5 | **0.47** | **0.31** | **0.35** | -0.09 | 1.00 | | | | | | | | | | | | | | | | | | | | | |
| DEM6 | 0.02 | 0.06 | -0.03 | 0.12 | 0.03 | 1.00 | | | | | | | | | | | | | | | | | | | | |
| DEM7 | -0.09 | -0.04 | -0.09 | 0.14 | -0.16 | **0.66** | 1.00 | | | | | | | | | | | | | | | | | | | |
| DEM8 | 0.00 | 0.01 | 0.01 | 0.11 | -0.01 | -0.17 | -0.10 | 1.00 | | | | | | | | | | | | | | | | | | |
| DEM9 | -0.11 | -0.16 | -0.13 | 0.03 | 0.02 | **0.73** | **0.47** | -0.11 | 1.00 | | | | | | | | | | | | | | | | | |
| DEM10 | **0.59** | **0.54** | **0.55** | 0.24 | **0.43** | -0.01 | -0.07 | 0.07 | -0.03 | 1.00 | | | | | | | | | | | | | | | | |
| DEM11 | -0.07 | -0.11 | -0.05 | 0.10 | 0.01 | -0.18 | -0.17 | **0.80** | -0.06 | 0.09 | 1.00 | | | | | | | | | | | | | | | |
| DEM12 | -0.04 | 0.05 | -0.05 | 0.05 | 0.14 | -0.06 | -0.01 | **0.34** | 0.01 | 0.03 | **0.37** | 1.00 | | | | | | | | | | | | | | |
| DEM13 | -0.05 | -0.13 | -0.14 | -0.02 | 0.02 | -0.17 | -0.08 | **0.49** | 0.02 | 0.05 | **0.42** | **0.58** | 1.00 | | | | | | | | | | | | | |
| DEM14 | 0.00 | -0.07 | -0.11 | 0.13 | 0.03 | **0.33** | **0.33** | 0.09 | **0.39** | -0.02 | 0.08 | 0.04 | 0.06 | 1.00 | | | | | | | | | | | | |
| DEM15 | -0.13 | -0.08 | -0.17 | 0.06 | -0.09 | **0.45** | **0.55** | 0.04 | **0.46** | -0.13 | 0.01 | 0.06 | 0.07 | **0.78** | 1.00 | | | | | | | | | | | |
| DEM16 | **0.43** | **0.41** | **0.48** | 0.24 | **0.34** | -0.03 | -0.19 | 0.04 | -0.10 | **0.42** | 0.00 | 0.16 | 0.00 | -0.08 | -0.20 | 1.00 | | | | | | | | | | |
| DEM17 | 0.21 | 0.18 | 0.09 | **0.44** | -0.02 | 0.12 | 0.26 | -0.11 | 0.04 | 0.20 | -0.09 | 0.01 | -0.22 | 0.03 | 0.03 | 0.26 | 1.00 | | | | | | | | | |
| DEM18 | 0.14 | 0.21 | 0.19 | 0.48 | -0.05 | 0.28 | 0.13 | -0.07 | 0.13 | 0.14 | 0.04 | 0.07 | -0.24 | 0.07 | 0.00 | 0.16 | **0.47** | 1.00 | | | | | | | | |
| DEM19 | 0.20 | 0.18 | 0.09 | **0.60** | 0.08 | 0.09 | 0.14 | -0.13 | -0.07 | 0.16 | -0.05 | 0.09 | -0.20 | 0.01 | 0.04 | 0.15 | **0.63** | **0.51** | 1.00 | | | | | | | |
| DEM20 | 0.26 | 0.05 | 0.09 | **0.43** | 0.08 | -0.02 | -0.03 | -0.02 | 0.02 | 0.12 | 0.04 | -0.04 | -0.04 | -0.01 | 0.00 | 0.15 | **0.39** | **0.52** | **0.63** | 1.00 | | | | | | |
| DEM21 | 0.17 | 0.09 | -0.10 | **0.55** | 0.02 | 0.10 | 0.14 | -0.11 | 0.03 | 0.14 | -0.01 | -0.03 | -0.21 | 0.00 | 0.01 | 0.09 | **0.42** | **0.39** | **0.66** | **0.42** | 1.00 | | | | | |
| DEM22 | 0.29 | 0.15 | 0.14 | **0.51** | 0.07 | 0.15 | 0.27 | -0.07 | 0.11 | 0.29 | -0.07 | 0.05 | -0.19 | 0.13 | 0.06 | 0.26 | **0.76** | **0.48** | **0.73** | **0.53** | **0.52** | 1.00 | | | | |
| DEM23 | -0.06 | -0.20 | -0.23 | -0.09 | -0.04 | -0.12 | -0.11 | **0.44** | 0.03 | 0.03 | **0.45** | **0.41** | **0.61** | 0.07 | 0.05 | -0.15 | -0.03 | 0.07 | -0.06 | 0.16 | -0.11 | 0.02 | 1.00 | | | |
| DEM24 | -0.02 | 0.03 | 0.00 | 0.00 | -0.06 | -0.05 | -0.04 | **0.62** | -0.06 | 0.00 | **0.48** | **0.48** | **0.44** | -0.07 | -0.04 | 0.10 | -0.10 | -0.10 | -0.14 | -0.13 | 0.03 | -0.11 | **0.40** | 1.00 | | |
| DEM25 | **0.42** | **0.40** | **0.33** | 0.02 | **0.38** | 0.09 | -0.04 | 0.01 | 0.04 | **0.43** | 0.01 | 0.10 | 0.05 | 0.02 | -0.03 | **0.37** | 0.00 | -0.05 | 0.00 | -0.07 | -0.01 | 0.09 | -0.08 | 0.09 | 1.00 | |
| DEM26 | 0.00 | -0.07 | -0.05 | **0.53** | -0.09 | 0.20 | 0.20 | -0.04 | 0.16 | -0.01 | 0.03 | 0.07 | -0.04 | 0.15 | 0.19 | 0.08 | **0.39** | **0.45** | **0.68** | **0.46** | **0.56** | **0.57** | 0.07 | -0.07 | -0.07 | 1.00 |

Table (4.7): Anti-image correlation matrix for energy management adoption drivers

| | DEM1 | DEM2 | DEM3 | DEM4 | DEM5 | DEM6 | DEM7 | DEM8 | DEM9 | DEM10 | DEM11 | DEM12 | DEM13 | DEM14 | DEM15 | DEM16 | DEM17 | DEM18 | DEM19 | DEM20 | DEM21 | DEM22 | DEM23 | DEM24 | DEM25 | DEM26 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DEM1 | **0.77[a]** | | | | | | | | | | | | | | | | | | | | | | | | | |
| DEM2 | -0.35 | **0.70[a]** | | | | | | | | | | | | | | | | | | | | | | | | |
| DEM3 | 0.16 | -0.44 | **0.64[a]** | | | | | | | | | | | | | | | | | | | | | | | |
| DEM4 | 0.03 | 0.11 | -0.07 | **0.80[a]** | | | | | | | | | | | | | | | | | | | | | | |
| DEM5 | -0.23 | 0.16 | -0.23 | 0.27 | **0.64[a]** | | | | | | | | | | | | | | | | | | | | | |
| DEM6 | -0.13 | -0.12 | 0.18 | -0.07 | -0.15 | **0.55[a]** | | | | | | | | | | | | | | | | | | | | |
| DEM7 | 0.01 | 0.12 | -0.15 | 0.00 | 0.11 | -0.52 | **0.64[a]** | | | | | | | | | | | | | | | | | | | |
| DEM8 | -0.02 | -0.23 | 0.10 | -0.21 | -0.10 | 0.06 | -0.10 | **0.61[a]** | | | | | | | | | | | | | | | | | | |
| DEM9 | 0.18 | 0.10 | -0.03 | 0.04 | -0.04 | -0.66 | 0.17 | 0.08 | **0.59[a]** | | | | | | | | | | | | | | | | | |
| DEM10 | -0.26 | -0.15 | -0.30 | -0.20 | -0.15 | 0.08 | -0.02 | 0.10 | -0.13 | **0.76[a]** | | | | | | | | | | | | | | | | |
| DEM11 | 0.06 | 0.25 | -0.08 | 0.07 | 0.03 | 0.02 | 0.12 | -0.73 | -0.05 | -0.17 | **0.65[a]** | | | | | | | | | | | | | | | |
| DEM12 | 0.09 | -0.17 | 0.20 | 0.02 | -0.25 | 0.22 | -0.12 | 0.23 | -0.13 | 0.13 | -0.21 | **0.48[a]** | | | | | | | | | | | | | | |
| DEM13 | -0.05 | 0.04 | 0.01 | -0.24 | 0.05 | 0.09 | -0.10 | -0.17 | -0.09 | -0.11 | 0.11 | -0.47 | **0.67[a]** | | | | | | | | | | | | | |
| DEM14 | -0.16 | 0.08 | 0.03 | -0.21 | -0.15 | 0.07 | 0.19 | -0.02 | -0.09 | 0.09 | -0.04 | 0.07 | 0.00 | **0.53[a]** | | | | | | | | | | | | |
| DEM15 | 0.14 | -0.15 | 0.02 | 0.14 | 0.11 | -0.04 | -0.37 | -0.03 | -0.06 | -0.03 | 0.01 | -0.09 | 0.03 | -0.78 | **0.59[a]** | | | | | | | | | | | |
| DEM16 | -0.06 | 0.01 | -0.20 | -0.09 | -0.09 | -0.19 | 0.28 | -0.03 | 0.14 | -0.06 | 0.06 | -0.24 | -0.03 | -0.04 | 0.05 | **0.72[a]** | | | | | | | | | | |
| DEM17 | -0.04 | -0.08 | 0.16 | -0.05 | 0.03 | 0.21 | -0.19 | 0.10 | -0.13 | 0.03 | -0.07 | 0.19 | -0.02 | 0.14 | -0.10 | -0.28 | **0.74[a]** | | | | | | | | | |
| DEM18 | 0.08 | -0.13 | -0.20 | -0.17 | 0.18 | -0.35 | 0.09 | 0.04 | 0.11 | 0.02 | -0.10 | -0.34 | 0.34 | -0.17 | 0.22 | 0.07 | -0.24 | **0.67[a]** | | | | | | | | |
| DEM19 | 0.15 | -0.16 | -0.01 | -0.21 | -0.16 | -0.26 | 0.17 | 0.06 | 0.37 | 0.02 | -0.04 | -0.30 | 0.10 | 0.08 | -0.08 | 0.28 | -0.29 | 0.16 | **0.74[a]** | | | | | | | |
| DEM20 | -0.30 | 0.15 | -0.07 | -0.06 | -0.07 | 0.25 | 0.04 | 0.00 | -0.25 | 0.21 | -0.02 | 0.31 | -0.17 | 0.25 | -0.24 | -0.16 | 0.21 | -0.38 | -0.41 | **0.64[a]** | | | | | | |
| DEM21 | -0.03 | -0.16 | 0.44 | -0.23 | -0.17 | 0.21 | -0.14 | 0.25 | -0.12 | -0.15 | -0.15 | 0.22 | 0.06 | 0.05 | 0.00 | -0.02 | 0.13 | -0.14 | -0.25 | 0.01 | **0.69[a]** | | | | | |
| DEM22 | -0.10 | 0.16 | -0.09 | 0.05 | 0.10 | 0.11 | -0.24 | -0.18 | -0.14 | -0.16 | 0.18 | -0.15 | 0.23 | -0.27 | 0.26 | -0.07 | -0.47 | 0.09 | -0.25 | -0.15 | -0.07 | **0.78[a]** | | | | |
| DEM23 | 0.04 | 0.04 | 0.21 | 0.28 | -0.01 | -0.05 | 0.15 | -0.01 | 0.08 | -0.23 | -0.08 | -0.01 | -0.43 | -0.06 | 0.01 | 0.24 | -0.07 | -0.24 | 0.08 | -0.19 | 0.16 | -0.14 | **0.65[a]** | | | |
| DEM24 | -0.05 | 0.07 | -0.25 | 0.05 | 0.21 | -0.19 | 0.05 | -0.45 | 0.06 | 0.15 | 0.11 | -0.36 | 0.06 | 0.09 | 0.01 | -0.06 | -0.08 | 0.18 | 0.11 | 0.04 | -0.42 | 0.08 | -0.24 | **0.60[a]** | | |
| DEM25 | -0.13 | -0.14 | 0.04 | 0.00 | -0.13 | -0.04 | 0.02 | 0.13 | -0.04 | -0.11 | -0.11 | 0.04 | -0.06 | 0.02 | -0.04 | -0.15 | 0.11 | 0.05 | -0.03 | 0.11 | 0.07 | -0.11 | 0.05 | -0.11 | **0.84[a]** | |
| DEM26 | -0.01 | 0.16 | -0.12 | -0.08 | 0.10 | -0.01 | 0.05 | 0.00 | -0.11 | 0.17 | -0.02 | 0.11 | -0.14 | 0.08 | -0.15 | -0.16 | 0.22 | -0.13 | -0.37 | 0.15 | -0.20 | -0.20 | -0.12 | 0.08 | 0.01 | **0.81[a]** |

a. Measures of Sampling Adequacy(MSA)

Table (4.8): KMO and Bartlett's test for energy management adoption drivers

**KMO and Bartlett's Test**

| Item | | Factor analysis run description | |
|---|---|---|---|
| | | First Run | Final Run |
| Number of included variables | | 26 | 19 |
| Number of extracted factors | | 6 | 4 |
| Kaiser-Meyer-Olkin Measure of Sampling Adequacy. | | 0.68 | 0.71 |
| Bartlett's Test of Sphericity | Approx. Chi-Square | 1099.87 | 752.38 |
| | df | 325 | 171 |
| | Sig. | 0.00 | 0.00 |
| Cronbach's alpha | | 0.79 | 0.75 |

However, after removing the item *DEM12* on the basis of its low MSA value < 0.5, as described above and rerun factor analysis, the communality values for all variables changed and the model for the second run with the remaining 25 variables resulted in two variables only with communality values less than 0.5, which were :

1- *"Government support for researchers in energy management in construction industry" DEM16*, with a communality value equals to 0.495.
2- *"Availability of building code requirements for energy saving and management" DEM25*, with a communality value equals to 0.485.

The variable with the lowest communality value of these two variables was superseded and removed from the next run of factor analysis ( third run). Each time the analysis repeated the extraction communality values for all variables should be checked and verified. Any variable with communality value less than 0.5, should be removed in the next run. Finally, it was found that each of the two variables should be removed to proceed to the next run of factor analysis. In addition the final solution should include variables with communalities more than 0.5 to be acceptable (Larose, 2006). As shown in Table (4.9), the final solution communalities for the remaining 19 drivers were greater than 0.5, and then, this solution satisfied communality requirements.

Table (4.9) : Communality values of energy management adoption drivers
"First run & Final run"

| Item | Extraction communality | |
|---|---|---|
| | First Run | Final Run " Eighth run" |
| DEM1 | 0.647 | 0.613 |
| DEM2 | 0.682 | 0.731 |
| DEM3 | 0.656 | 0.650 |
| DEM4 | 0.649 | 0.579 |
| DEM5 | 0.629 | Removed in 7th run |
| DEM6 | 0.808 | 0.794 |

Table (4.9) : Communality values of energy management adoption drivers "First run & Final run". "Continued"

| Item | Extraction communality | |
|---|---|---|
| | First Run | Final Run " Eighth run" |
| DEM7 | 0.708 | 0.696 |
| DEM8 | 0.835 | 0.834 |
| DEM9 | 0.688 | 0.673 |
| DEM10 | 0.643 | 0.682 |
| DEM11 | 0.727 | 0.736 |
| DEM12 | 0.635 | Removed in 2ed run |
| DEM13 | 0.710 | 0.518 |
| DEM14 | 0.825 | Removed in 6th run |
| DEM15 | 0.824 | 0.560 |
| DEM16 | 0.511 | Removed in 4th run |
| DEM17 | 0.582 | 0.564 |
| DEM18 | 0.509 | Removed in 8th run |
| DEM19 | 0.811 | 0.837 |
| DEM20 | 0.649 | 0.515 |
| DEM21 | 0.558 | 0.590 |
| DEM22 | 0.738 | 0.746 |
| DEM23 | 0.693 | Removed in 5th run |
| DEM24 | 0.732 | 0.580 |
| DEM25 | 0.497 | Removed in 3ed run |
| DEM26 | 0.638 | 0.660 |

*Extraction Method: Principal Component Analysis.*
*Items "variables" were removed during several runs of factor analysis.*

**2. Cumulative percentage of variance explained by the extracted factor solution.**

The number of the significant factors delivered from factor solution can be determined by total variance explained the number of the significant factors can be determined. Table (4.10) below explains the total variance explained for the 26 variables involved in the first run. This table shows that 6 components with eigenvalue larger than one which mean that six factors (components) can be extracted from the 26 drivers (variables) involved in the first run on the base of eigenvalue greater than one. Thus, the extracted six components (factors) would explain 67.63% of the total variance, which mean that, a considerable amount of the common variance shared by the 26 variables (drivers) could be accounted for by these six factors (De Vaus, 2002). On the basis of this value, the six-factor solution obtained from the initial 26 variables (drivers) can be considered acceptable because the cumulative variance explained by these six factor equals to 67.63% which is greater than the threshold of 50% of total variance explained as specified by Meyers et al. (2006) and Mane and Nagesha (2014). The first component with eigenvalue equals to 5.36 and explained the higher value of the total variance of the data with 18.66%, whereas the sixth component with eigenvalue equals to

1.08 and explained the lowest value of the total variance which equals to 4.42 %. Thus, the first component is the most important factor as it explains the most variance of the data. However, the total variance explained by the final run (eighth run) of factor analysis on drivers for energy management equals to 66.10 and including four factors extracted from the remaining 19 variables (drivers) as shown in Table (E.1) in appendix (E).

Table (4.10): Total variance explained by factor analysis for the first run of the drivers for energy management adoption.

| Component | Initial Eigenvalues | | | Extraction Sums of Squared Loadings | | | Rotation Sums of Squared Loadings | | |
|---|---|---|---|---|---|---|---|---|---|
| | Total | % of Variance | Cumulative % | Total | % of Variance | Cumulative % | Total | % of Variance | Cumulative % |
| 1 | 5.36 | 20.62 | 20.62 | 5.36 | 20.62 | 20.62 | 4.85 | 18.66 | 18.66 |
| 2 | 3.86 | 14.85 | 35.47 | 3.86 | 14.85 | 35.47 | 3.80 | 14.61 | 33.27 |
| 3 | 3.46 | 13.30 | 48.77 | 3.46 | 13.30 | 48.77 | 3.49 | 13.41 | 46.69 |
| 4 | 2.66 | 10.24 | 59.01 | 2.66 | 10.24 | 59.01 | 2.64 | 10.15 | 56.83 |
| 5 | 1.16 | 4.47 | 63.48 | 1.16 | 4.47 | 63.48 | 1.66 | 6.38 | 63.21 |
| 6 | 1.08 | 4.15 | 67.63 | 1.08 | 4.15 | 67.63 | 1.15 | 4.42 | 67.63 |
| 7 | 0.95 | 3.67 | 71.30 | | | | | | |
| 8 | 0.87 | 3.35 | 74.65 | | | | | | |
| 9 | 0.81 | 3.11 | 77.76 | | | | | | |
| 10 | 0.70 | 2.70 | 80.46 | | | | | | |
| 11 | 0.66 | 2.55 | 83.00 | | | | | | |
| 12 | 0.59 | 2.25 | 85.26 | | | | | | |
| 13 | 0.57 | 2.17 | 87.43 | | | | | | |
| 14 | 0.53 | 2.02 | 89.45 | | | | | | |
| 15 | 0.45 | 1.72 | 91.17 | | | | | | |
| 16 | 0.37 | 1.42 | 92.59 | | | | | | |
| 17 | 0.33 | 1.26 | 93.85 | | | | | | |
| 18 | 0.31 | 1.19 | 95.04 | | | | | | |
| 19 | 0.28 | 1.07 | 96.11 | | | | | | |
| 20 | 0.22 | 0.85 | 96.97 | | | | | | |
| 21 | 0.20 | 0.76 | 97.73 | | | | | | |
| 22 | 0.16 | 0.62 | 98.35 | | | | | | |
| 23 | 0.15 | 0.57 | 98.92 | | | | | | |
| 24 | 0.11 | 0.41 | 99.33 | | | | | | |
| 25 | 0.09 | 0.36 | 99.69 | | | | | | |
| 26 | 0.08 | 0.31 | 100.00 | | | | | | |

Extraction Method: Principal Component Analysis

3. **Loaded items and extracted factors properties.**

In previous discussion, several tests were performed to specify the suitability of data for factor analysis and the appropriateness of the generated solution. Therefore, if all criteria identified by these tests fulfilled, the rotated component matrix table should be produced by Varimax method. This table should be investigated by different ways to accept the solution produced and the variables involved in any run of factor analysis. Table (4.11) below provided the rotated component matrix table for the first run of factor analysis for the 26 drivers for energy management application, in which six factors were created. Note that many variables may be removed on the basis of any criteria discussed earlier in this study before arriving to the this table (such as *DEM12* to be removed on because its MSA< 0.5). So that, the first run rotated component matrix table provided here for clarification only about the procedures to be followed to accept the created solution. However, rotated component matrix table should be examined only when all previous requirements of factor analysis satisfied, such as MSA values, communalities, KMO, p-value for Bartlett's test of sphericity and etc.,. In general, this table should be inspected for three conditions to accept its contents and then the solution emerged from the data involved in this run. These three inspections have been conducted for the first run results provided in Table (4.11), as follows:

**First condition: Each item should has at least one factor loading value equal or more than (0.5).**

This condition established according to the suggestions provided by Hair et al. (2010) and Mane and Nagesha (2014), who imposed that, only the items (variables) with factor loading equal or more than 0.5 to be appeared on this table and considered for factor explanation. Any factor loading value less than 0.5 was blanked and didn't appeared in this table. Therefore, only factor loadings equal or more than 0.5 are shown in Table (4.11). So that, each one of the 26 items (drivers) included in the first run had at least one factor loading greater than 0.5 which revealed that each one of these items can be loaded at least on one factor of the extracted factors. According to the previous discussion, all the 26 items (drivers) considered suitable for factor analysis on the basis of factor loading values only because each one of the involved items loaded on one factor at least with a factor loading equal or more than 0.5.

**Second condition: Each one of the extracted factors should include at least three items to be acceptable.**

This condition requires the number of the items in the extracted factor not be less than 3 items, if the number of items included in the extracted factor less than three items, this factor should be removed from analysis by removing the involved items. By reviewing the data included in Table (4.11), it can be seen that each one of the first four factors had more than 3 items (drivers) loaded on it. As shown also, eight items loaded on the first factor, seven items loaded on the second factor, six items loaded on the third factor and four items loaded on the fourth factor, which indicated that these four factors can be accepted. However, the fifth factors involved two items only and the sixth factor hadn't involved any item loaded on it which mean that no any concept reflected by this factor and it can be discarded and neglected in interpretation and discussion. Hence, the fifth factor has been removed because it involved two items (drivers) only *DEM14* and *DEM15*. So that, these two items should be removed one by one and new analysis run should be conducted if any variable removed and all checks should be performed. Finally, each one of the extracted factors involved three or more as shown in the Table (4.13) which depicts the final run (eighth run) solution results, and indicated that the first factor of the final four factors solution contained seven items (drivers) and each one the second, third and fourth factors implied four items (drivers), which demonstrated the suitability of the obtained solution in the final run (eighth run)

**Third condition: The item loaded on more than one factor with factor loading greater than 0.5 should be removed "no cross-loading items".**

An item that has significant loading factor value equal or more than 0.5 and loaded on more than one factor which consequently, the problem of cross-loading existed. Cross loaded items should be removed and analysis repeated excluded these items. Refer to Table (4.11) ,the item DEM15 was a cross-loading item because it was loaded on fourth and the fifth factors with factor loadings 0.51 and 0.74, respectively. Consequently, this item should be removed and analysis should repeated.

Finally, several attempts (runs) implied eight runs of factor analysis were performed to get an acceptable final solution satisfied all factor analysis requirements. Each run was checked for all criteria suggesting the suitability of the data as discussed in chapter 3 and with accordance to the steps discussed above. The final solution revealed the presence of four distinct factors with an eigenvalue more than one and involved the remaining 19 drivers (variables) of the proposed 26 main variables in study questionnaire. In the same line, the scree plot presented in Figure (4.4) below revealed a clear after the fourth component in the final solution. As shown in Table (4.8), the reduced data set of 19 variables (drivers) resulted in acceptable a Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy of 0.71 ( larger than 0.5), and the Bartlett test of sphericity, reached statistical significance with (Chi-square= 1209.36) and significance level of (p-value = 0.000) which was lower than 0.05. The final four factors solution from the remaining 19 items were satisfied in the final solution as described here:

1. The correlation matrix of the remaining variables involved several correlation coefficients between 0.3-0.9 without any value larger than 0.9 as shown in Table (E.1) in appendix E.
2. Measure for sampling adequacy (MSA) values have been larger than 0.5 as shown in the anti-image correlation matrix presented in Table (E.2) of appendix E.
3. Communalities of the remaining 19 items displayed in Table (4.9) were larger than 0.5.
4. Commutative variance of the four factor extracted in the fourth (final) run was 62.88% which was larger than 50 % as required, and shown in Table (E.3) of appendix E.
5. Table (E.4) in Appendix E displayed that each one of the four factors extracted in the fourth run had more than two items loaded on it with factor loading more than 0.5 ( for example, the first factor included seven items loaded with factor loading more than 0.5) and without any cross-loading item. In addition, the commutative percent of variance explained by this solution is larger than 50%.

Table (4.11): Rotated component matrix for the first run of the drivers for energy management adoption.

| Item | Component | | | | | |
|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 |
| DEM19 | 0.89 | | | | | |
| DEM22 | 0.82 | | | | | |
| DEM26 | 0.76 | | | | | |
| DEM21 | 0.74 | | | | | |
| DEM17 | 0.73 | | | | | |
| DEM4 | 0.72 | | | | | |
| DEM20 | 0.72 | | | | | |
| DEM18 | 0.69 | | | | | |
| DEM2 | | 0.78 | | | | |
| DEM10 | | 0.78 | | | | |
| DEM1 | | 0.75 | | | | |
| DEM3 | | 0.75 | | | | |
| DEM25 | | 0.67 | | | | |
| DEM16 | | 0.65 | | | | |
| DEM5 | | 0.63 | | | | |
| DEM8 | | | 0.78 | | | |
| DEM13 | | | 0.78 | | | |
| DEM24 | | | 0.77 | | | |
| DEM11 | | | 0.75 | | | |
| DEM12 | | | 0.73 | | | |
| DEM23 | | | 0.71 | | | |
| DEM6 | | | | 0.88 | | |
| DEM9 | | | | 0.78 | | |
| DEM7 | | | | 0.77 | | |
| DEM14 | | | | | 0.84 | |
| DEM15 | | | | 0.51 | 0.74 | |

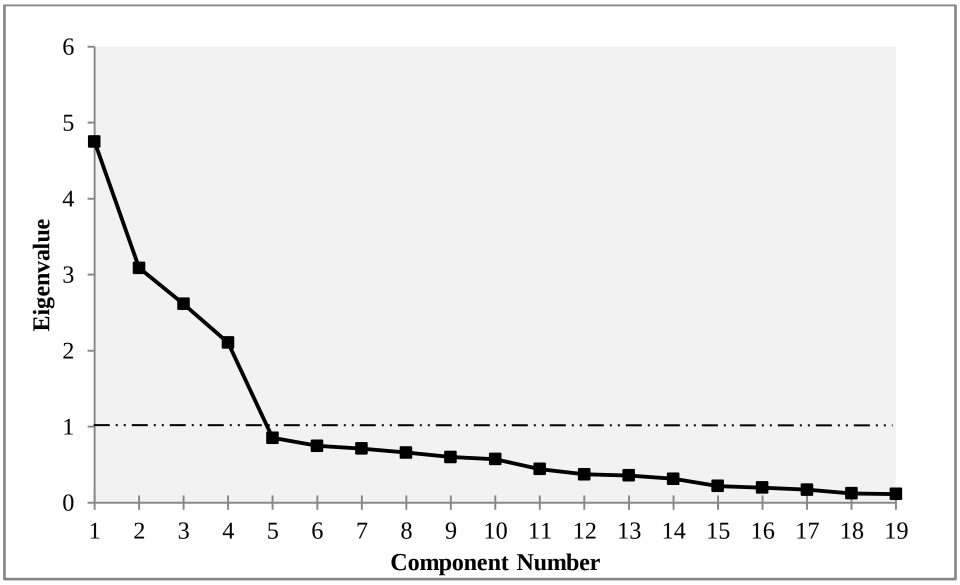


Figure (4.4): Scree plot of the final run of energy management adoption drivers

It should be noted that 7 variables was dropped from the analysis as they didn't satisfy at least one of the factor analysis requirements, which were *(DEM12, DEM25, DEM16, DEM23, DEM14, DEM5 and DEM18)* and arranged according to their precedence in deletion from the performed analysis. The items (drivers) removed from the main data and the reason for its removal can be shown in Table (4.12), and described as follows;

1- *DEM12* has been removed in the second run of factor analysis because its MSA value equals to 0.476 and less than the acceptance level ( at least equal or more than 0.5);
2- *DEM25* has been removed in the third run because its communality value equals to 0.485 and less than the acceptance level ( at least equal or more than 0.5);
3- *DEM16* has been removed in the fourth run because its communality value equals to 0.485 and less than the acceptance level ( at least equal or more than 0.5);
4- *DEM23* was removed in the fifth run because it was loaded alone on one factor (sixth factor) and it was cross-loading item ( third and sixth factors);
5- *DEM14* was removed in the sixth run because it was loaded with another item only (*DEM15*) on one factor (fifth factor) and it was cross-loading item ( third and fifth);
6- DEM5 was removed in the seventh run because it was loaded alone on one factor (fifth factor);
7- *DEM18* was removed in the eighth run because its communality value equals to 0.489 and less than the acceptance level ( at least equal or more than 0.5);

On the basis of the restrictions for selecting only those items which have got the loadings equal to or more than 0.5, seven variables were loaded on the first factor and accounted for 22.77% of the total variance, four other variables were loaded on the second factor and accounted for 14.57% for the total variance, four other variables were loaded on the third factor and accounted for 14.40 % for the total variance, the last four variables were loaded on the fourth factor and accounted for 14.35 % for the total variance. Table (4.12) below summarizes the results, procedures and actions taken in every run of factor analysis for the drivers of energy management to get the acceptable final four factors solution.

**4. Reliability measure of the extracted factors.**

After extracting the final factors and identifying the variables loaded on each factor, it becomes important to check the reliability of each factor (component). By indicating if the variables formed each factor explains the measure within this factor based on Cronbach's Alpha (Cα) value, which should be more than 0.7 according to Pallant (2005). Overall reliability (Cronbach's α) of the remaining 19 variables was 0.75, also, the reliability scores (Cronbach's α) were calculated for individual extracted factors which ranged from 0.82 to 0.89, indicating adequate internal consistency, and higher Cronbach's α values provided greater internal consistency of the studied variables (Pallant, 2005).

Table (4.12): Factor analysis runs and related data of energy management adoption drivers

| Requirement | Requirement threshold | Run number | | | |
|---|---|---|---|---|---|
| | | First | Second | Third | Fourth |
| Reliability of remaining variables | Cα > 0.7 | 0.79 | 0.79 | 0.78 | 0.78 |
| MSA values check for each variable | > 0.5 | Satisfied except<br>▪ DEM12 = 0.48 | Satisfied | Satisfied | Satisfied |
| KMO index | > 0.5 | 0.68 | 0.71 | 0.69 | 0.70 |
| Bartlett's test of sphericity "Sig" | < 0.05 | 0.00 | 0.00 | 0.00 | 0.00 |
| Communality values | > 0.5 | Satisfied except;<br>▪ DEM25 = 0.497 | Satisfied except;<br>▪ DEM25 = 0.485,<br>▪ DEM16= 0.495 | Satisfied except;<br>▪ DEM16 = 0.491 | Satisfied |
| Cumulative % of variance explained | > 50% | 67.63 % | 68.55% | 69.80% | 71.05% |
| No. of variables in each extracted factor | > 2 | Satisfied except;<br>▪ Factor no.5 (2 Items)<br>▪ Factor no.6 ( 0 Items) | Satisfied except;<br>▪ Factor no.5 (2 Items)<br>▪ Factor no.6 (1 Item) | Satisfied except;<br>▪ Factor no.5 (2 Items)<br>▪ Factor no.6 (1 Items) | Satisfied except;<br>▪ Factor no.5 ( 2 Items)<br>▪ Factor no.6 (1 Items ) |
| Factor loading of the variable | => 0.5 | Satisfied | Satisfied | Satisfied | Satisfied |
| Cross loading variable | => 0.5 on two factors or more | ▪ DEM15 | ▪ DEM23 | ▪ DEM23 | ▪ DEM23 |
| Action taken for the next run "Removed item" | | DEM12 "MSA value < 0.5" | DEM25 "Communality value < 0.5" | DEM16 "Communality value < 0.5" | DEM23 "Cross loading on Factor No.3 & Factor No.6" "Loaded alone on Factor No.6" |

Table (4.12): Factor analysis runs and related data of energy management adoption drivers “Continued”

| Requirement | Requirement threshold | Run number | | | |
|---|---|---|---|---|---|
| | | Fifth | Sixth | Seventh | Eight |
| Reliability of remaining variables | Cα > 0.7 | 0.78 | 0.78 | 0.78 | 0.75 |
| MSA values check for each variable | > 0.5 | Satisfied | Satisfied | Satisfied | Satisfied |
| KMO index | > 0.5 | 0.69 | 0.71 | 0.72 | 0.71 |
| Bartlett's test of sphericity “Sig” | < 0.05 | 0.00 | 0.00 | 0.00 | 0.00 |
| Communality values | > 0.5 | Satisfied | Satisfied | Satisfied except;<br>▪ DEM18 = 0.489 | Satisfied |
| Cumulative % of variance explained | > 50% | 67.44% | 68.20% | 64.95% | 66.09% |
| No. of variables in each extracted factor | > 2 | Satisfied except<br>▪ Factor no.5 (2 Items) | Satisfied except Factor no.5 (1 Item) | Satisfied | Satisfied |
| Factor loading of the variable | => 0.5 | Satisfied | Satisfied | Satisfied | Satisfied |
| Cross loading variable | => 0.5 on two factors or more | ▪ DEM14,<br>▪ DEM15 | No cross loading items | No cross loading items | No cross loading items |
| Action taken for the next run “Removed item” | | DEM14 “Cross loading on Factor No.3 & Factor No.5” “Loaded with another item only on Factor No.5” | DEM5 “Loaded alone on Factor No.5” | DEM18 “Communality value < 0.5” | Final solution (All requirements were satisfied) |

- Extraction method : Principal components analysis (PCA).
- Rotation method : Orthogonal Varimax rotation.
- MSA: Measure of sampling adequacy for each variable.
- KMO: Kaiser-Meyer-Olkin measure of sampling adequacy.
- No. of extracted factors : Factors with eigenvalue larger than 1.
- Cross loading variable: Variable that loaded at 0.50 or higher on two or more factors.

Table (4.13): Final results of factor analysis for energy management adoption drivers

| Item | Energy management adoption drivers " variables & factors" | Factor loading | Eigenvalue | % variance explained | Cornbach' α |
|---|---|---|---|---|---|
| **Factor no.1:** ***Economic and Financial*** | | | | | |
| DEM19 | Cost saving gained from adopted energy management strategies. | 0.90 | 4.75 | 22.77 | 0.89 |
| DEM22 | Availability of different energy types, sources and alternatives in local market. | 0.82 | | | |
| DEM26 | Availability of new energy saving solutions, products and tools in local market. | 0.78 | | | |
| DEM21 | Decrease price levels of energy saving technology for construction industry. | 0.77 | | | |
| DEM4 | Imposed governmental tax for energy use and emissions on construction companies. | 0.73 | | | |
| DEM20 | High energy amounts and costs required during onsite works in the project. | 0.73 | | | |
| DEM17 | Availability of the financial support for energy saving strategies/plans and investments. | 0.71 | | | |
| **Factor no.2:** ***Institutional and Legal*** | | | | | |
| DEM2 | Strength and enforcement of the governmental requirements for onsite construction energy saving. | 0.85 | 3.09 | 14.57 | 0.83 |
| DEM10 | Adoption of energy performance contracts (EPC) in local construction market. | 0.80 | | | |
| DEM3 | Contractor energy performance is one criteria of the company rating in local construction sector | 0.80 | | | |
| DEM1 | Existence of government regulations related to energy consumption and saving issues for construction industry. | 0.76 | | | |
| **Factor no.3:** ***Organizational and Managerial*** | | | | | |
| DEM8 | Existence of sustainability policy within the contractor organization. | 0.94 | 2.62 | 14.40 | 0.82 |
| DEM11 | Availability of long term energy management strategies within the construction companies. | 0.85 | | | |
| DEM24 | Improved onsite working conditions. | 0.76 | | | |
| DEM13 | Contractor willingness to satisfy client/donor requirements regarding energy issues. | 0.70 | | | |

Table (4.13): Final results of factor analysis for energy management adoption drivers *"Continued"*

| Item | Energy management adoption factors and variables | Factor loading | Eigenvalue | % variance explained | Cornbach' α |
|---|---|---|---|---|---|
| ***Factor no.4: Education and Information*** | | | | | |
| DEM6 | Increased education level of the contractor employees. | 0.88 | | | |
| DEM9 | Availability of experts in energy efficiency in construction industry | 0.82 | | | |
| DEM7 | Construction employees awareness of onsite energy use and problems. | 0.81 | 2.73 | 14.35 | 0.83 |
| DEM15 | Availability of information on successfully implemented energy management practices in construction. | 0.73 | | | |

*Kaiser-Meyer-Olkin measure of sampling adequacy = 0.654*
*Bartlett's test of sphericity: x2= 752.38,df=171,p-value =0.00*
*Total variance explained (%) = 66.09 %*
*Total reliability Cornbach's α = 0.754*

Each factor of the final four factors solution, were subjected to reliability analysis based on the variables loaded on it. (4.13) depicts the 19 remaining variables in four factors, and their respective factor loadings, explained variances, eigenvalues and Cornbach's α for each of the four factors. This table was prepared in the descending order with the topmost factor at the beginning and the items in each factor where arranged in descending order according to its importance based on its loading values in the factor contained it.

***<u>Third phase of factor analysis for energy management adoption drivers: Factors naming and interpretation.</u>***

As mentioned above, four factors were extracted. They were assessed and numbered in a descending order on the basis of the amount of variance explained by each one. This ranking order showed that, while the first factor has the strongest effect with the highest percent of total variance explained with 22.7%, in driving the adoption of energy management, the fourth factor has the weakest as it has the smallest percent of total variance explained with 14.35%. Then, each factor was subjectively labelled in accordance with factor loading values and the correlation between the individual items loaded on it. Several classification method proposed in many studies that can help in naming the factors extracted here, such as, Qi et al. (2010) who classified the factors influencing the construction contractor to adopt green construction practices into environmental regulations, managerial concerns and project stakeholders' pressure.

Based on an examination of the inherent relationships among the variables under each component, the extracted factors were labeled as follows:

- **Factor no.1**: ***Economic and Financial***; explains 22.7% of the total variance and contains 7 items.
- **Factor no.2:** ***Institutional and Legal***; explains 14.57% of the total variance and contains 4 items.
- **Factor no.3:** ***Organizational and Managerial***; explains 14.40% of the total variance and contains 4 items.
- **Factor no.4:** ***Education and Information***; explains 14.35% of the total variance and contains 4 items.

The proposed naming of the extracted factors were discussed with experts and academics to validate the naming of the principal factors. One expert only recommended to add the word cultural to the fourth factor. Finally, the discussion participants all agreed with the names as the suitable representation of the principal factors. Figure (4.5) below describes the final results of the factors extracted and percent of variance explained from each factor.

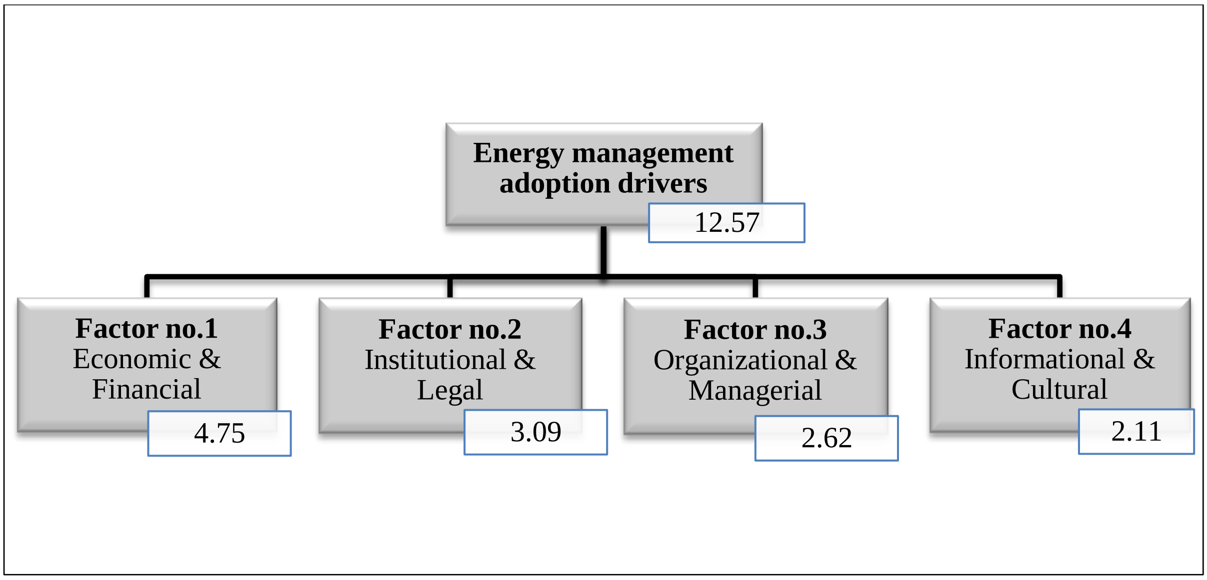


Figure (4.5): Final factors extracted from factor analysis for energy management adoption drivers.

- **Interpretation of the principal factors that driving the local contractors to adopt energy management.**

Based on the results obtained from the preformed factor analysis process, which resulted in four principal factors of the 19 remaining variables in the final solution, and after labeling the extracted factors and validating its names, the following interpretation can be provided;

***a) Factor no.1 : Economic and Financial***

It is clear that the seven items\variables that loaded on this factor\component are related to economic and financial issues that can drive local contractors to adopt energy management in construction projects. This grouping would appear to be logical and the factor can be termed *"Economic and Financial"*. This factor accounts for 22.77% of the total variance explained. All of the loaded items enjoy acceptable factor loadings (> 0.50), which suggests that these items are relatively associated with this factor. According to factor analysis theory, the first factor accounts for the largest part of total variance of the data. Hence, It implies that economical and financial aspects considered as the most important driving forces for energy management adoption in construction companies in Gaza Strip. The responses to these items revealed that majority of the contractors see that economic and financial related issues need to be discussed and actions to be taken to increase the application of energy management in local construction companies. This view strongly supported by the increased contractors focus toward efforts that reducing their energy consumption by changing their management behavior and by encouraging firms' management and workers to follow suit in order to ascertain repeat business (Davies et al. 2013a). In the same line, Jiang (2008) argued that economic approaches such as fiscal and tax policies can be used to give guidance and support for energy strategies and programming, and contribute to the drive for energy conservation, application of new energy technologies and products, and development of new and renewable energies.

Generally, the importance of this factor can be appeared in the economic benefits attained by the companies applying energy management in their activities such as cost savings and lower taxes. For example, Kahlenborn et al. (2010) reported that by introducing an energy management system, organizations can save up to 10 % of its energy costs in the initial years after implementation by systematically identifying the weak points in its energy consumption and addressing them with basic measures. In fact, it is well recognized that economic benefits such as cost effectiveness are one of the most important considerations for decisions of implementing any development in construction industry (De Groot et al., 2001; Ochieng et al., 2014). In the line with this result, De Groot et al. (2001) recognized that economic benefits have the greatest influence in driving Dutch firms to adopt energy saving technologies, which were reflected in the highest ranks given to two economic and finance related driving forces which were cost reductions resulting from lowered energy use and direct fiscal subsidies. These findings strengthened the viewpoints presented in the previous researches such as, Bassioni et al. (2010) and Cagno and Trianni (2013), which asserted that this dimension is very important for increasing the adoption of energy management in construction. In Palestinian context, economic and financial issues can highly promote local contractors to adopt energy management during project construction, if they perceived that the cost of complying is lower than the benefits of complying.

By studying the correlation matrix between the variables\items that forms the first factor\component the results obtained from factor analysis can be verified. In fact, the main concept of the exploratory factor analysis is to group several variables (items) into smaller number of factors on the basis of the correlation between these variables and the extracted factors may be treated as new variables can account for the pattern of correlations between the involved variables (De Vaus, 2002; Kothari.2004). Therefore, each one of the four factors extracted on the basis of the correlation between the variables (items) formed the factor. So that, the first factor *"Economic and Financial"* attained as a result of the relationship between the variable comprised this factor. However, De Vaus (2002) assumed that, the strength of the relationship between each pair of variables can be considered relatively strong if they are correlated with a correlation coefficients (r) larger than 0.3. The correlation matrix Table (4.14) revealed that there is a statistically significant correlation among the four drivers within the *"Economic and Financial"* factor with correlation coefficients ranged between 0.39 to 0.76. Therefore, the results obtained by factor analysis about the first factor *"Economic and Financial"* can be validated. For example, the driver *DEM4* correlated with each one of the other six drivers\variables *DEM17*, *DEM19*, *DEM20*, *DEM21*, *DEM22* and DEM26 with a correlation coefficients (r) equal to 0.44, 0.60, 0.43, 0.55, 0.51 and 0.53 with the items, respectively. Accordingly, grouping these seven drivers under on factor is statistically persuasive .

Table (4.14): Pearson correlations between the items "drivers" in *"Economic and Financial"* factor

| Item | DEM4 | DEM17 | DEM19 | DEM20 | DEM21 | DEM22 | DEM26 |
|---|---|---|---|---|---|---|---|
| DEM4 | 1.00 | | | | | | |
| DEM17 | 0.44** | 1.00 | | | | | |
| DEM19 | 0.60** | 0.63** | 1.00 | | | | |
| DEM20 | 0.43** | 0.39** | 0.63** | 1.00 | | | |
| DEM21 | 0.55** | 0.42** | 0.66** | 0.42** | 1.00 | | |
| DEM22 | 0.51** | 0.76** | 0.73** | 0.53** | 0.52** | 1.00 | |
| DEM26 | 0.53** | 0.39** | 0.68** | 0.46** | 0.56** | 0.57** | 1.00 |

***b) <u>Factor no.2 : Institutional and Legal</u>***

The second factor was labelled as "*Institutional and Legal*", accounts for 14.75% of the total variance and comprises 4 items. This factor was labelled in accordance with the characteristics of the set of individual items loaded on it. Under this factor\component, the correlations between the four variables can be distinguished by the institutional and regulative issues, and to which extent the energy management can be executed in accordance with these issues. Therefore, these issues were placed into the "*Institutional and Legal"*. All of these items have acceptable factor loadings (> 0.50). *"Institutional and Legal"* factor would involve changing current rules and legislation to include and enforce energy efficient practices, as well as publishing new guidelines that illustrate the new practice to be implemented by the firms thus encouraging them to adopt and implement energy management within their organizations to comply with existing and new legislation. The stakeholders governing this factor are national and local government, regulatory bodies such as standards organizations and those bodies responsible for regulating the professionals and the industry sectors.

Throughout this research, it is encouraging to see that the respondents having a positive attitude towards legislations and its related aspects. However, several studies viewed that, energy management in construction can be achieved by meeting the mandatory regulations or statutory targets (Jiang, 2008; AlSanad, 2015). This result also supported by previous studies which showed the role of the regulation and laws in promoting the practice of energy efficient construction (Tan et al., 2011; Shi et al., 2013). Generally, construction industry requires certain rules to be in place to engage in adopting economically sustainable activities. These rules can take the form of contracts or regulations, which set the parameters for transactions (Wyk et al., 2011). Commitment to the proposed regulations and laws reflects that the firm appears to be more serious in promoting energy conservation practices (Wai et al., 2006). Subrahmanya (2006) declared that energy conservation and efficiency improvement is a major objective of government policy in any economy. Besides that, changes to the regulatory framework, particularly building regulations, are considered to be effective means for a behavioral shift in the construction sector (Majdalani et al., 2006). So that, assuming the existence of governmental regulations concerning sustainability and energy issues in Palestine, the respondents considered complying with these regulations as one of the best ways to drive the implementation of energy management in local construction companies.

However, the Palestinian building regulations are criticized for falling short of pushing the industry to achieve its full potential. To effectively integrate environment and development in the policies and practices of the country, it is essential to develop and implement integrated, enforceable and effective laws and regulations that are based upon sound social, ecological, economic and scientific principles. The traditional function of a government in relation to the environment after establishing related regulation and laws, is to control the commitment of the related parties to these regulations. This reinforcement can be performed by different forms and measures such as taxes, fees, strict policies and subsidies to stimulate energy efficient technologies and techniques development and adoption. Additionally, by introducing governmental standards related to sustainable construction, stakeholders awareness will be raised and they will be encouraged to adopt sustainable practices in the construction industry (AlSanad, 2015). Whilst some government regulations and laws to assist in implementing sustainable and energy efficient construction are in place in some countries, most remain optional. Akinbami and Lawal (2009) argued that lack of standards enforcement will result in regulations noncompliance and will also ultimately discourage the organizations to invest in improving the efficiency of their activities and products. UNEP (2006) explained different causes may result in weak enforcement of environmental policies and legislation. One reason for limited enforcement is that governments allocate insufficient funds for policy implementation and enforcement. Plus authorities are often hesitant to fine companies, afraid that they might move to other parts of the country, and thereby causing a loss of local jobs.

An evaluation of the linear relationship between the items included in the second factor was measured using Pearson’s correlation. Table (4.15) below, presents the correlation matrix between the four items forming the second factor called “Institutional and Legal”. From this table, it is clear that the four items are significantly correlated together with correlation coefficient larger than 0.3 and can be considered acceptable degree (De Vaus, 2002). By inspecting the correlation coefficient in this matrix , it can be seen than the smallest value of ( r) equals to 0.41 between the items DEM1 and DEM10, and the largest value equal to 0.64

between the items DEM2 and DEM3. On this basis, the correlation analysis implies that the grouping factor of these four items can determine the company direction to adopt energy management. In addition, correlation coefficient values between the four items validates the solution obtained from factor analysis.

Table (4.15): Pearson correlations between the items "drivers" in *"Institutional and Legal"* factor

| Item | DEM1 | DEM2 | DEM3 | DEM10 |
|---|---|---|---|---|
| DEM1 | 1 | | | |
| DEM2 | 0.58** | 1 | | |
| DEM3 | 0.41** | 0.64** | 1 | |
| DEM10 | 0.59** | 0.54** | 0.55** | 1 |

***c) <u>Factor no.3 : Organizational and Managerial</u>***

Management always plays a significant role in industry development. In fact, for the energy management program to be successful, initially, a firm top management commitment to all requirements is essential (Kannan and Boie, 2003). Hence, the third factor gathered all those items which are related to the organization and management decision on issues related to energy management. These items are the result of the organizational structure, the management processes and leadership within the project team. Therefore, this factor was named as *"Organizational and Managerial"* and accounts for 14.40 % of the total variance and comprises four items. The majority of these items enjoyed relatively large factor loadings (> 0.50). The combination of these four items reflects the intensity of support given by management to adopt energy management. These drivers are mainly internal factors which reflect the sustainability culture and commitments of a firm (Apeaning and Thollander, 2013). A survey conducted by Qi et al. (2010) showed that, managerial concerns are the most important driver for the adoption of green practices by contractors. Organizational and managerial factors provide assistance in the formation of the company strategies which considered as an important factor that can affect the success of energy management implementation process. According Kahlenborn et al. (2010), the starting point for a functioning energy management program is the formulation of an managerial polices and systems procedures for the company. Bassioni et al. (2010) indicated that management requirements and standards are very important in the construction industry which may have influence on the companies to implement an energy management system. Tan et al. (2011) reported that, the uptake and implementation of energy management can be facilitated when consideration of sustainability issues had been incorporated within the policies of the organizations. However, the growing concern about energy and environmental issues caused energy policy receiving increased attention and considered as an important section of the overall sustainability policy in the firm (Ndayiragije, 2006). As mentioned earlier, this result demonstrated the significance of the organizational managerial drivers on the local contracting organizations as a factor facilitating the energy management implementation process.

On the basis of the previous results, the organization energy policy and strategies, top management commitment to client\donor requirements managers and improved onsite working conditions are internal and organizational issues explaining why local contractors may use energy saving and management practices. This result reflected in the significant correlations between the items\variables involved in the third factor which called *"Organizational and Managerial"*, Table (4.16). This significant correlations rationalize the grouping obtained by factor analysis for these for drivers under reduced on factor which mean that this factor can effect energy management adoption as the effect of the four drivers as a whole. In addition, correlation coefficient in Table (4.16) ranged from 0.42 to 0.8 and all values larger than 0.3 which can make us confident about the result induced from factor analysis in this study.

Table (4.16): Pearson correlations between the items "drivers" in *"Organizational and Managerial"* factor

| Item | DEM8 | DEM11 | DEM13 | DEM24 |
|---|---|---|---|---|
| DEM8 | 1.00 | | | |
| DEM11 | 0.80** | 1.00 | | |
| DEM13 | 0.49** | 0.42** | 1.00 | |
| DEM24 | 0.62** | 0.48** | 0.44** | 1.00 |

***d) <u>Factor no.4: Education and Information.</u>***

The fourth factor was labelled *"Education and Information"* include four items addressing this particular theme. It explains about 14.35% of the total variance and includes the items addressing aspects related to the size and availability energy management information. It is mentioned that all the four items appear with acceptable large loadings (> 0.50) on this factor. The key elements of *"Education and Information"* factor refers to the energy knowledge and education activities that present in construction contracting companies and the industry as a whole. Collectively, this group of items demonstrates the local contractors' perception of the importance of the availability of information and staff knowledge related to energy management, and how such an this item contributes positively or otherwise to their tends to apply energy management. Hence, education and availability of more information will push the adoption of energy management forward. Wide range of information activities can be designed and provided including media campaigns, technical publications, training, education and information centers. Indeed, these activities often create enough awareness and concern for firms' managers and employees to remain effective in energy use. In the same line, Apeaning (2012) contended that, information available to a firm is an important decision making parameter and at the same time aids in the cost effective implementation of energy efficiency programs. Vesma (2012) argued that, informational and human factors are key to energy saving in the workplace as energy-aware workforce know what to do and have less of a tendency to work in an energy-wasteful manner. On other hand, one of the most important facts that, increased information and knowledge by contractors employees and professionals education on energy management requirements will improve the future compliance to these requirements (Ates and Durakbasa, 2012). Kannan and Boie (2003) noted that, employee education on energy conservation issues was given high priority before implementing any energy saving measures in industry. This result is supported by the results obtained by Thollander et al. (2013), who found that information-related driving forces were located in the lowest positions to drive industries to implement energy efficiency. The significance of energy information and culture availability in Gaza strip to improve application of sustainable measures and energy management was highlighted by Muhaisen and Ahlbäck (2012). A closer examination, however, revealed that energy management education and training programs are scarce in Gaza Strip, and local contractors have no experience with formal energy management education and training; thus the respondents were more inclined to agree with statements referring to increased application of energy management through the skills gained by education and training courses

The data provided in the correlation matrix in Table (4.17) confirmed the appropriateness of the results obtained from factor analysis. It can be seen that, the four drivers\items that clustered under on heading as shown in the fourth factor which was named as *"Education and Information"* are correlated with a correlation coefficient more than 0.3. So that, the grouping of these four drivers in one factor can be considered satisfactory.

Table (4.17): Pearson correlations between the items "drivers" in *"Education and Information"* factor

| Item | DEM6 | DEM7 | DEM9 | DEM15 |
|---|---|---|---|---|
| DEM6 | 1.00 | | | |
| DEM7 | 0.66** | 1.00 | | |
| DEM9 | 0.73** | 0.47** | 1.00 | |
| DEM15 | 0.45** | 0.56** | 0.46** | 1.00 |

## 4.6 Key barriers to the implementation of energy management in local contracting companies during project construction.

Construction industry is complex in nature and construction projects are unique, hence the practitioners face various constraints and barriers while trying to adopt new technologies and techniques (Memon and Zin, 2010). Understanding which barriers limit the use of energy efficient measures within the industrial sector is crucial to develop the most effective methods to overcome such barriers (Trianni et al., 2013). In addition, exploring specific impeding barriers to energy management adoption is very important in describing the sources of the gap between awareness and application levels of energy management in local construction sector. In this section, the fifth part of the questionnaire involved a total of 31 barriers (BEM1 to BEM31) to the adoption of energy management activities in local contracting companies which were devised from the literature and interviews with experts from both academics and industry. The respondents were asked to indicate their agreement about the importance and frequently faced barriers, which prohibit the energy management adoption in local construction industry. The primary data collected from the fifth part of the questionnaire was analyzed and discussed from the perspective of the contractors. Descriptive and inferential statistics were prepared and presented about these barriers so that, the fourth objective of this study can be achieved. Although the most significant barriers were identified using ranking analysis, some of them are likely to be inter-related with each other through an underlying structure of primary factors. In order to obtain a concise list of energy management barriers, a factor analysis was performed. The subsequent parts provides detailed discussions about the analysis results of these barriers data.

### 4.6.1 Relative Importance Indexes (RIIs) and ranking of the barriers for energy management adoption

Analysis results regarding to the proposed barriers including, the mean score (MS), standard deviation (SD), relative importance index (RII) and ranking of the barriers, together with its one sample t-test results (t-values and p-values) are shown in Table (4.18). The barriers were ranked based on RII values which have computed for comparison purposes. From the ranking assigned to each barrier to adopt energy management, the most important factors inhibiting the adoption of energy management in local construction sector can be identified. Additionally, RIIs values of all barriers were presented in Figure (4.6) to provide a clearer picture of the consensus reached by the respondents

However, every one of the devised barriers has a standard deviation value less than 1.0, which suggests some agreement among respondents in how these barriers were interpreted (Wai et al., 2011). In furtherance, discussion on the one sample t-test below is expected to give some possible reasons.

This study interested in the barriers normally considered by the local contractors in Gaza Strip. The one-sample t-test was conducted to further validate the perception of the contractors to the barriers to energy management application. The one-sample t-test is used to test whether the mean of a single variable differs from a specified value. Based on that, the neutral of the five point scale that has been used for rating the items was an average of (3).

Thus, this test was conducted at a specified value (hypothesized value) of 3 and a confidence interval of 95%. As shown in Table (4.18), all the p-values are less than 0.05, all t-values are positive and larger than the critical value (1.99), which indicated that, the mean of population from which the sample is taken with (MS=3.65, SD=0.27) was significantly different from the specified value (hypothesized value = 3). Positive t-value validates the results as the sample mean is larger than the hypothesized value. Webb et al. (2006) argued that, the data set will be in agreement with the upper scale of the Likert data when the mean scores are above the criterion mean. Therefore, it can be concluded that, the respondents agreed to the importance of the proposed 31 variables (barriers) in impeding the application of energy management in local construction sector. Specifically, these results suggest that when any of these barriers exist, the degree of application level of energy management will reduced.

The overall results from the questionnaire analysis show that, *"Additional costs needed to improve the company energy efficiency" BEM12*, yielded the highest RII of 86.84%, indicating that it is the most frequently encountered challenge. *"Lack of the company staff awareness on the importance of energy management during onsite construction" BEM18*, was ranked second highest RII of 85.79% while *"Difficulties to access technical information and expertise related to energy management in construction" BEM8*, was ranked as the least critical challenge, with RII of 62.89%.

In fact, cost considered as the main potential barrier for the implementation of sustainable construction in construction industry (Ochieng et al., 2014). Therefore, the barrier named *"Additional costs needed to improve the company energy efficiency" BEM12,* with (MS=4.34, RII=86.84%, SD=0.62 and p-value=0.00), was ranked in the first position of the barriers impeding the adoption of energy management in local contracting companies. This result suggests that, the local contractors are well aware and concern about the financial issues related to any development proposed. The general perception about sustainable construction is that the introduction of sustainable construction practices will increase costs and reduce profit (Reffat, 2004). Tiwari (2001) and Hwang and Tan (2012) have discussed this perception and argued that green construction projects would result in the increment of total project costs as relatively new technologies and systems are required to fulfill the expected performances of buildings constructed. The majority of this cost increase is due to the procurement of sustainable materials (from new source) and tools, equipment for energy conservations and time and cost necessary to integrate more energy saving practices into projects (Saravanan, 2011).

Kibert (2008) reported that, the increase in capital costs in delivering a more sustainable building compared to a conventional building has been quoted to be around 2%. However, this increase in investment could lead to life-cycle savings that are 10 times greater than the incremental cost increase. In general, Shi et al. (2013) argued that all industrial stakeholders concern about any additional cost in the first instance when considering the implementation of new norms or new technologies. Therefore, any cost related decision concerning energy efficiency is based on a trade-off between the immediate cost and the future decrease in energy expenses expected from increased efficiency (WEC, 2004). This challenge especially evident in developing countries because the vast majority of sustainable materials, products and technologies currently require have to be imported resulting in its higher price and hence, higher initial costs (Shari and Soebarto, 2012). Palestine as well; where the most binding constraints on economic activity in West Bank and Gaza are the uncertainty and extra cost of doing business because of the difficulty of access not only to external markets but also to local markets; resulting from the Israeli occupation (World Bank, 2006). This border closure makes the fluctuation in availability and higher prices of energy management materials and tools which dominantly imported from outside.

In the Palestinian context, it is difficult for local contractors to invest in energy conservation activities because no empirical study has thrown light on the initial cost required for energy management and efficiency improvement and the benefits of energy management and its effects on economic performance. In addition, the profit driven culture in construction industry can demonstrate the role of any additional cost in limiting the development of energy management system, because cost, quality and scheduling have been the determinants ensuring maximum benefits to the construction firms (Khalfan et al. 2015). As in Palestine, the construction industry is highly profit focused, as most project contracts are given to the contractor offering the lowest price. Hence, to award more contracts, contractors in Gaza Strip are working on diminishing profit margins given the economic problems and the high competition in a relatively small market. Accordingly, any sustainable initiatives that may increase their incurred cost such planning costs and materials and appliances costs for more energy saving are not considered of importance.

This evidence is in line with a study conducted by Shen and Tam ( 2002) in Hong-Kong, which concluded that, construction contractors considered sustainable construction practices as inevitably leading to extra costs and resources and thus unlikely to attract their interest. On other hand, this result is similar to the previous survey conducted by Shi et al. (2013) about green building and sustainable construction, who has ranked the additional cost derived from green construction requirements as the most critical barrier to its use. Additionally, many respondents of the study conducted by Abidin (2009) believed that the main factor that impeded the implementation of sustainable construction in the Malaysian construction industry is the financial constraint emerged from the increased project cost, which is in line with the outcome of this research. Forth more, high implementation cost was ranked by Bassioni et al. (2010) as the second internal barriers to environmental management system implementation in the Egyptian construction industry. In their market survey, Powmya and Abidin (2014) identified that among construction practitioners in Oman, there is a belief that sustainable construction practices will raise the cost of construction projects without a quantifying benefits; a perception that poses an important challenge. In contrast to this result, Shari and Soebarto (2012) found that, the most common explanation for the lack of achievement of a sustainability objective was total absence or lack of expressed interest in the client's requirements of the development.

Table (4.18): Analysis results of the barriers for energy management adoption barriers

| No. | Energy management adoption barrier | MS | RII | SD | t-value | P-value (2-tailed) | Rank |
|---|---|---|---|---|---|---|---|
| BEM12 | Additional costs needed to improve the company energy efficiency | 4.34 | 86.84 | 0.62 | 18.78 | 0.00 | 1 |
| BEM18 | Lack of the company staff awareness on the importance of energy management during onsite construction. | 4.29 | 85.79 | 0.65 | 17.31 | 0.00 | 2 |
| BEM10 | Company senior management doesn't provide support for energy saving activities | 4.09 | 81.84 | 0.79 | 12.11 | 0.00 | 3 |
| BEM26 | High costs of energy management options (measures/technologies). | 4.07 | 81.32 | 0.70 | 13.29 | 0.00 | 4 |
| BEM27 | Construction energy costs are not sufficiently important compared with other costs. | 4.05 | 81.05 | 0.76 | 12.01 | 0.00 | 5 |
| BEM9 | The contract documents do not impose any special conditions/specifications for onsite energy management. | 4.00 | 80.00 | 0.75 | 11.65 | 0.00 | 6 |
| BEM1 | Lack of governmental legislations for environment protection and energy conservation in construction sector. | 3.95 | 78.95 | 0.85 | 9.75 | 0.00 | 7 |
| BEM28 | Lack of budget funding to adopt energy management practices and technologies. | 3.91 | 78.16 | 0.68 | 11.69 | 0.00 | 8 |
| BEM6 | High competition between the local contracting companies working in the construction sector. | 3.89 | 77.89 | 0.79 | 9.84 | 0.00 | 9 |
| BEM19 | Lack of the client/donor awareness of the importance of energy management during onsite construction. | 3.87 | 77.37 | 0.74 | 10.28 | 0.00 | 10 |
| BEM3 | Lack of government support/ incentives for energy management in construction industry. | 3.83 | 76.58 | 0.82 | 8.78 | 0.00 | 11 |
| BEM11 | Company management lack interest in onsite energy costs and consumption issues. | 3.72 | 74.47 | 0.67 | 9.48 | 0.00 | 12 |
| BEM13 | The company lacks long-term vision and it is short-term oriented. | 3.71 | 74.21 | 0.67 | 9.25 | 0.00 | 13 |
| BEM29 | Low profit margins gained from adopting energy management practices. | 3.71 | 74.21 | 0.78 | 7.94 | 0.00 | 14 |
| BEM20 | Resistance to change from traditional practices to more energy efficient practices. | 3.67 | 73.42 | 0.70 | 8.35 | 0.00 | 15 |
| BEM23 | Lack of technical skills\knowledge on construction energy management technologies. | 3.67 | 73.42 | 0.72 | 8.14 | 0.00 | 16 |

Table (4.18): Analysis results of the barriers for energy management adoption barriers "Continued"

| No. | Energy management adoption barrier | MS | RII | SD | t-value | P-value (2-tailed) | Rank |
|---|---|---|---|---|---|---|---|
| BEM21 | Management believe that there is no/little scope for the company energy performance improvement . | 3.63 | 72.63 | 0.59 | 9.41 | 0.00 | 17 |
| BEM5 | Lack of audit and quantitative evaluation tools for the energy performance of the construction companies . | 3.58 | 71.58 | 0.79 | 6.41 | 0.00 | 18 |
| BEM24 | Lack of training and education in energy management, sustainable design and construction. | 3.55 | 71.05 | 0.74 | 6.53 | 0.00 | 19 |
| BEM4 | Lack of energy management codes and regulation in construction. | 3.53 | 70.53 | 0.79 | 5.80 | 0.00 | 20 |
| BEM14 | The company lacks of procedures or strategies to promote sustainable construction | 3.49 | 69.74 | 0.68 | 6.21 | 0.00 | 21 |
| BEM31 | Uncertain local economic environment. | 3.47 | 69.47 | 0.72 | 5.73 | 0.00 | 22 |
| BEM15 | Poor enforcement of the governmental legislations related to energy issues in construction industry. | 3.42 | 68.42 | 0.75 | 4.87 | 0.00 | 23 |
| BEM16 | The company lacks of ethical standards and corporate social responsibility. | 3.36 | 67.11 | 0.72 | 4.27 | 0.00 | 24 |
| BEM25 | Lack of demonstration examples on energy management in construction industry | 3.29 | 65.79 | 0.73 | 3.47 | 0.00 | 25 |
| BEM7 | Fragmentation of the construction process (Increased industry parties and divided processes). | 3.26 | 65.26 | 0.64 | 3.58 | 0.00 | 26 |
| BEM22 | Conflicts of interest within the project members (owner/consultant /contractor). | 3.26 | 65.26 | 0.64 | 3.58 | 0.00 | 27 |
| BEM17 | Tight project duration makes the management concerned about the time required to adopt energy management practices. | 3.21 | 64.21 | 0.57 | 3.20 | 0.00 | 28 |
| BEM30 | Lack of innovative energy technologies /equipment in local market. | 3.20 | 63.95 | 0.82 | 2.11 | 0.03 | 29 |
| BEM2 | No specific person or committee assigned to deal with onsite energy issues. | 3.17 | 63.42 | 0.70 | 2.13 | 0.03 | 30 |
| BEM8 | Difficulties to access technical information and expertise related to energy management in construction. | 3.14 | 62.89 | 0.67 | 1.89 | 0.04 | 31 |
| | Overall energy management adoption barriers | 3.65 | 73.00 | 0.27 | 20.61 | 0.00 | --- |

- *MS: Mean Score* *RII: Relative Importance Index* *SD: Standard Deviation*
- *Critical t-value (two-tailed): at degree of freedom (df) = [N-1] = [76-1] = 75 and significance level 0.05 equals "1.99"* *The hypothesized population mean is the critical rating at 3.*

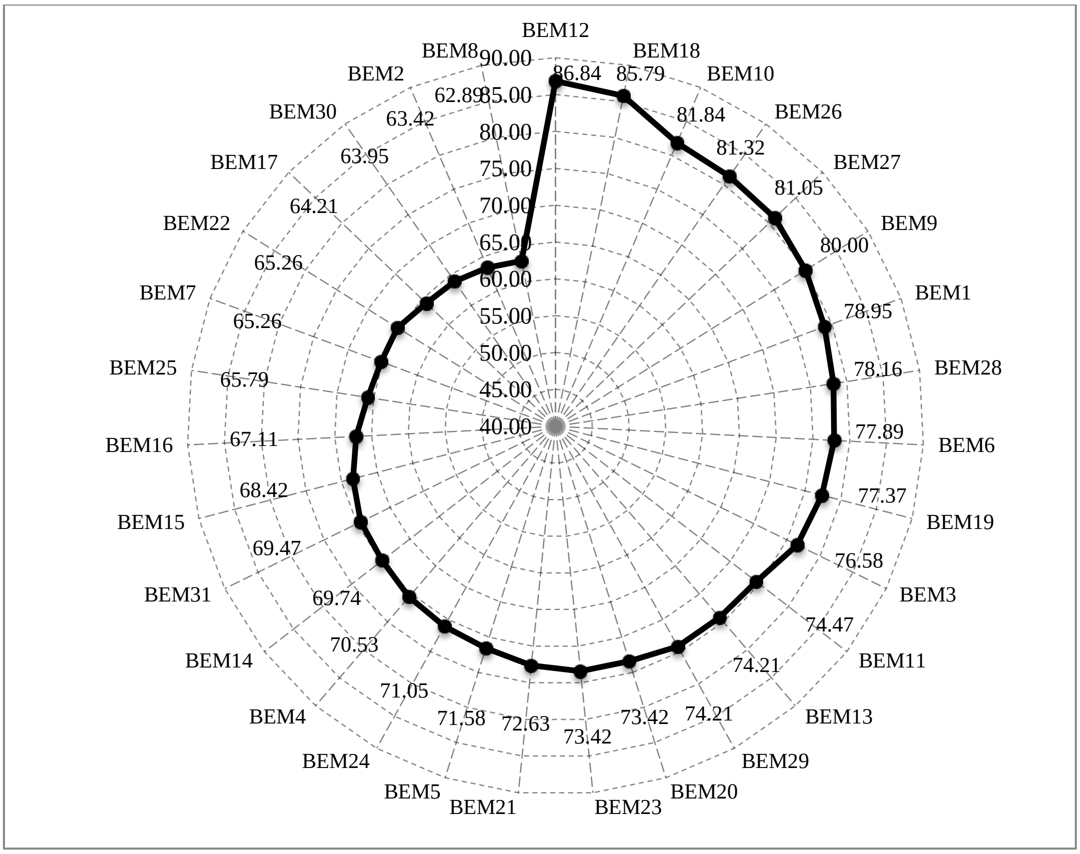


Figure (4.6): RII of energy management application barriers *"BEM1 to BEM31"*

*"Lack of the company staff awareness on the importance of energy management during onsite construction" BEM18,* was ranked as the second barrier with (MS=4.29, RII=85.79%, SD=0.65 and p-value=0.00). It is not surprising to get this result as local contractors employees and technical staffs have a low level of energy awareness and they were engaged in inappropriate energy-use habit. In reality, people will not take any steps to conserve energy if they are not aware of the importance of energy saving (Wai et al, 2009). As a result of this limited view of the responsibility beside the limited awareness of the cost and benefits of sustainable construction practices, there is a resistance among different staffs of the construction companies to change the conventional construction methods and processes to more sustainable ones (Häkkinen and Belloni, 2011). Hence, this low awareness level can be reflected in poor level of energy management application among the industries surveyed.

Wai et al. (2009) argued that, contractor employees playing an important role in using new techniques and technologies and there awareness level about the consequences of applying these technologies and requirements will affect the whole application of energy management system in the company and without awareness there will be no realistic action to conserve energy. The low level of awareness results in perceiving energy efficiency improvement issues as secondary to other important investments (Apeaning, 2012). Actually, the lack of or limited awareness of the potentials of energy efficiency is about the most important obstacle to wide-scale adoption of energy efficiency measures and technologies, generally and particularly in the buildings sector (Akinbami and Lawal, 2009). In the same line, Abidin (2009) reported that, the implementation of sustainable construction applications in construction requires working staff knowledge, consciousness and full understanding main sustainable construction actions. In general, the information and knowledge barriers are considered as the largest barrier to energy efficiency (Jarnehammar et al., 2008). The companies surveyed by Rettab and Brik (2008) mentioned that, the lack of knowledge is the main barrier to establishing a green supply chain in Dubai. In the same line , Bassioni et al. (2010) was ranked "Lack of awareness" as the first external barriers to the Environmental Management System (EMS) implementation in the Egyptian construction industry.

There are several reasons why raising energy awareness and improving energy-use behavior in local contracting companies are important. Firstly, construction sites have large number of workers compared to other industries and, therefore, human factor is critical to energy saving. Raising energy awareness among workers will help them to be more conscientious about energy saving in their life. Secondly, construction sites have a large number of energy consuming facilities and equipment. Most of the energy embedded in these facilities and equipment are still manually operated and, thus, to recommend ways for workers to use it effectively is imperative. In Palestine case, local contractors core teams including labors, technical, foreman and engineers were no attain adequate technical understanding of, or knowledge to actually implement, energy management practices. The results further revealed that improved awareness on sustainability issues could partly help to alleviate management and workers resistance to adopt energy management (Kahlenborn et al., 2010). Yaseen (2008) noted that an increase in efficiency and dissemination the awareness toward energy conservation through workshops and capacity building for the involved staff must be a priority for the Palestinian Territories in view of the fact that energy resources are so scarce.

Because energy management is a new concept in Palestine, it is important to convey the goals and benefits of energy management methods to all relevant construction stakeholders in order to achieve successful execution of sustainable construction projects. Educating the relevant parties in order to raise awareness of the energy management concept is vital in order to overcome several obstacles to the dissemination of sustainability in construction, such as the lack of awareness and knowledge of these methods and their benefits.

From the previous results, *"Company senior management doesn't provide support for energy saving activities" BEM10*, with (MS=4.09, RII=81.84%, SD=0.79 and p-value=0.00), was ranked in third place; this ranking partly stemmed from the first two barriers which are, the additional costs associated with energy efficient technologies and low awareness level about the importance of energy management application. In the same time, contractors also haven't implemented energy management as a means to competitiveness in local markets. UNIDO (2007) has validated this result by describing the central reasons for low management support to saving activities which were, firstly; a management focus on production as the core activity, not energy efficiency and secondly; lack of management understanding of operational costs and equipment life cycle cost. Really, without the support of senior managers, any energy management initiative is likely to falter ( Carbon Trust, 2011).

Respondents of this study also ranked the barrier *"No specific person or committee assigned to deal with onsite energy issues" BEM2,* in apposition directly before the end most barrier (position 30 of 31 barriers) with (MS=3.17, RII=63.42%, SD=0.70 and p-value=0.03).

Although its late position, this barrier considered important from the view point of the respondents as its MS > 3 and p-value < 0.05, which reflected the importance of assigning a specific person in local contracting companies to manage all energy issues during project construction. For that, ISO (2008) stipulated that, company top management should appoint an energy management representative with the appropriate skills and training to apply successful energy management program. Additionally, Vesma (2012) proposed that, the company should consider bringing in a consultant to help and advice when its management do not feel confident about conducting energy management activities or they lack the time to do so.

In fact, the local contractors level of knowledge and concerns to pay additional costs related to energy management activities leading the contracting companies to perform its projects without assigning a specific person or team to handle energy saving activities in its projects. Mainly, the salaries to be paid to a person with technical qualification to look into energy related activities considered as an additional cost to project and the concerns that accrued cost as a result of energy saving would not pay-off this dedicated person salaries. Furth more, Ates and Durakbasa (2012) considered the position and tasks of the this person or committee as the bigger problem to appoint them to manage all energy issues in the company. To overcome this problem, some countries provide regulations requiring the nomination of an energy manager in companies above a certain size especially, large companies in industry (WEC, 2004). The late position of this barriers to some extent can be attributed to the respondents consideration that many energy management activities in project construction can be done by other related professions such as the construction project manager or site engineer. In his study, Baloi (2003) found that the site manager and the supervisors were assigned the main responsibility for environmental management.

The least significant barrier of the thirty one that listed in the questionnaire is *"Difficulties to access technical information and expertise related to energy management in construction" BEM8*, with (MS=3.14, RII=62.89%, SD=0.67 and p-value=0.04). Access to information is a vital tool for investments decision making and implementation of industrial energy efficiency practices (Apeaning, 2012). However, information access difficulty may be caused by the lack of internet access in the company and very often by language barriers (UNEP, 2006). Ates and Durakbasa, (2012) argued that external relationship and strong contact with foreign countries/industry have a substantial impact on a company's approach to energy management. This case are not provided in Gaza Strip, as a result of different constraints on outside travel which imposed by borders closure with Israel and Egypt. Additionally, information collection and processing consume time and resources, which are especially difficult for small firms (Worrell and Price, 2001a). UNIDO (2007) pointed out that lack of knowledge and interest in energy efficiency delivered the limited ability of industrial companies to collect and evaluate information on energy efficient technologies and practices. In Gaza Strip, this can be explained by the fact that the industrial area not have research center in energy management and as, such information sharing among contracting firms in the local construction sector was quite low. In addition, without application of energy management in local construction sector, the information about it can't be provided and the contractor interest about it can't developed. Availability of expertise in the form of contractors and consultants, with a knowledge and experience on energy management, was another factor that emerged as affecting the success of the energy management implementation process. However, Gaza Strip lack of experienced persons in energy management and therefore, access to technical information about energy management can be more difficult. In the same line of this study, the lack of information has been confirmed as a common barrier hindering the company's energy efficiency improvement in several previous studies (e.g., Christofferson et al., 2006; Cagno and Trianni, 2013).

Kostka et al. (2013) suggested different sources of information for industrial companies to familiarize themselves with the latest energy efficiency technologies including the internet, company visits, or personal contacts, equipment suppliers and manufacturers and by attending trade exhibitions and reading relevant magazines. In the same line, construction parties rely on written materials (journals, proceedings, newspapers, websites) to improve their knowledge about sustainable construction. Other sources of knowledge are through education and higher learning; seminars and conferences; and experience with sustainable projects (Abidin, 2009). Currently, both technical and economic data on energy management are often available by different sources of information such as internet and published researches. However, these sources often fail to create enough awareness and concern for the local contracting companies to remain effective in using energy. Even when there is sufficient technical information available, the implementation process could be ineffective if there is a lack of support from the managerial team within the company.

The results of this section also suggest that *"Company management lack interest in onsite energy costs and consumption issues" BEM11,* and the fact that *"Resistance to change from traditional practices to more energy efficient practices" BEM20,* were other deterrents from a contractor's perspective. This is not only because of the lack of awareness, application and concern about energy management issue, but also because of the view that traditional practices of undertaking construction and maintenance projects are satisfactory. In this context, improving knowledge through the introduction of an educational and training programs in this sector would lead to more experienced individuals who can apply and publicize more energy efficient construction activities in their companies, thus promoting energy management and sustainable practices.

#### 4.6.2 Factor analysis of the barriers to energy management adoption in local construction sector.

When various items deemed to be related; hence, the factoring and rotation methods bring them together under a principal factor (Field, 2009). Therefore, deeper analysis by conducting factor analysis on the proposed energy management adoption barriers was presented in this part in order to help the local construction contractors to reduce the list of the most important barriers into more manageable principal factors. The fifth part of this study questionnaire (Appendix A) comprised 31 variables dealing with the barriers to energy management application issues that facing contracting organizations working in Gaza Strip. Data gathered from this part was subjected to factor analysis. Exploratory Factor Analysis (EPA) was performed using the principal component analysis as the extraction method and the varimax criterion as the rotation method. Factor analysis was employed to establish which of the listed barriers could be measuring aspects of the same underlying dimensions so that relationships and patterns can be easily interpreted and understood. Additionally, it is easier to focus on some key factors rather than having to consider too many variables that may be trivial (Yong and Pearce, 2013). Several issues have to be considered in determining whether a data set is suitable for factor analysis. If many variables violated any criteria of factor analysis requirement, these items should be removed one by one and the revised analysis run should subjected to all checks required until obtaining a satisfactory solution fulfilled all requirements. In order to assess the suitability of the data for the factor analysis, all the appropriate checks were performed, as mentioned previously in chapter three (Research methodology). Three main stages involved in completing the factor analysis process, including:

- **First phase: Preliminary analysis;**
- **Second phase: Factors extraction;**
- **Third phase: Factors naming and interpretation.**

## ***First phase of factor analysis for energy management adoption barriers: Preliminary analysis.***

Before factor analysis, the quality of data collected was assessed by performing several tests. In this part, the primary tests that proposed by several statistician are performed. Then factor analysis is performed to investigate into possible common features linking the 31 barriers. Here, all variables under the study are analyzed together to extract the underlining factors. The test related to this study data on the barriers for energy management adoption in local construction contracting firms described here, as follows:

### 1. Type of the study data (variables).

The sample was first examined for its suitability to the factor analysis application by investigating the data under study. The data collected from the questionnaire about energy management application barriers were measured on ordinal scale which justified its suitability for factor analysis according to Yong and Pearce (2013). Furth more, Rehbinder (2011) recommended a data to be subjected to a perceptive opinion of the respondents, so that it can easily create a reduced number of factors from the multiple variables. Accordingly, the proposed variables (barriers) for energy management in this study were suitable for factor analysis because it have been subjected to the opinion of the respondents about their agreement on the importance of each barrier in impeding the adoption of energy management in local construction sector and it was measured by using 5- points Likert scale.

### 2. Distribution of the data

With the base of Central Limit Theorem, the data collected about energy management adoption barriers can be considered normally distributed because sample size for this study was 76 and it was larger than 30 as proposed by Hair et al. (2010). Therefore, the normal distribution requirement for factor analysis application for this part of study has been satisfied as stipulated by (Field, 2009).

### 3. Sample size

For factor analysis, Tabachnick and Fidell (2007) and Hair et al. (2010) recommend having at least 5 cases for each item to be adequate in most cases. In this part, this factor analysis contained in total 76 respondents and 31 variables (barrier), which means that the analysis has 76/31= 2.45 respondents per variable which is less than 5. One can therefore conclude that the sample size is limited compared to the number of variables. It was however not possible to collect more data or respondents because of time restrictions, and the analysis had to continue with a sample size of 76. This number is larger than 50. Therefore, the sample size in this study can be considered adequate for factor analysis based on Winter et al. (2009) and Sapnas and Zeller (2002).

### 4. Data reliability test.

The first stage of the quantitative analysis was related to the reliability test where the reliability of the questionnaire was tested according to the Cronbach's alpha measurement. Through the analysis that has been done, the alpha reliability of the scale of 31 items (barriers) in this study was 0.81 for the items indicating that 81% of the variance of the total scores of all barriers can be attributed to systematic variance. Since the result was achieved above 0.7, it showed that all items have indicated internal consistency and achieved high reliability as proposed by Pallant (2005). Due to high coefficient values of Cronbach's alpha, it can be concluded that the respective respondents were admitted the importance of the barriers to be further investigated for the proposed objective. After the reliability of the data confirmed, we can proceed to the other checks required for factor analysis. In the next stages of data analysis process, the data was analyzed using factor analysis in order to enhance the results of Cronbach's alpha.

### 5. Factorability of the correlation matrix.

The starting point for all factor analysis techniques is the correlation matrix. Checking the correlation matrix can indicate if there is a patterned relationship amongst the 31 variables (Yong and Pearce, 2013). Accurately, to ensure a good factor analysis, the variables should be correlated to some extent, but not be perfectly correlated (De Vaus, 2002; Malhotra and Birks, 2006). Tabachnick and Fidell (2007) and Field (2009) recommended that, if there are some correlations above 0.3 and none of these greater than 0.9, it is valid to carrying on with the analysis. Therefore, by inspecting the correlation matrix for the 31 barriers which presented in Table (4.19), it can be seen that the correlation coefficients between these variables satisfied this assumption. Correlation matrix results showed that each one of these variables has some correlation with other variables at a correlation coefficient larger than 0.3 as shown in the bolded values in Table (4.19). In the same time, no correlation coefficient has a value larger than 0.3. These values of the correlation coefficients for energy management barriers showed an adequate correlation amongst several of these variables. For example, the variable (barrier) *BEM1* has some correlation with the variables *BEM3*, *BEM4*, *BEM5*, *BEM9* and *BEM15* with a correlation coefficients equal to 0.62, 0.70, 0.55, 0.78 and 0.58, respectively. The values of these coefficients are larger than 0.3 and smaller than 0.9, so that, the variable *BEM1* should be retained in further analysis as it has a considerable relationship with others. In the same order, all barriers involved was checked for its suitability for factor analysis.

### 6. Items Correlation Matrix Adequacy *"Kaiser-Meyer-Olkin (KMO) Measure of Sampling Adequacy/Bartlett's Test of Sphericity"*

Prior performing a factor analysis, the Measure of Sampling Adequacy (MSA) for the 31 individual variables (barriers) can be found by looking at the bolded diagonal elements in the anti-image correlation matrix provided in Table (4.20), (Hair et al., 2010). All variables should have a MSA above 0.5 and preferably higher (Field, 2009). In this case, all variables (31 barriers) were higher than the threshold, therefore, it was decided to keep all the variables for further analysis. For example, from this table the MSA values for the variables *BEM1*, *BEM5*, *BEM10*, *BEM24* equal to 0.76, 0.71, 0.72 and 0.8, respectively, which are larger than 0.5. The diagonal of the anti-image correlation matrix should be checked each time when factor analysis process repeated.

In addition, Kaiser-Meyer-Olkin (KMO) and Bartlett's Test of sphericity are commonly used to measure the sampling adequacy in factor analysis (Malhotra and Birks, 2006). In general, the Bartlett's test of sphericity is significant when (p-value <0.05), and when the value of the KMO index is above 0.5, suggesting the data set is suitable for factor analysis (Mane and Nagesha, 2014). For the first run of the 31 barrier before deleting any variable, Table (4.21) shows the KMO value at 0.72 (should be > 0.50), and the Bartlett's test for sphericity with (Chi-square = 1385.59) at p-value= 0.00 level (Should be < 0.05) hence meeting the requirements. As the requirements of KMO value and the Barlett's test of sphericity are both achieved, an initial capture of the factors can be conducted using 31 variables/items of the barriers for energy management application in construction industry, using the principal component analysis approach with exploratory factor analysis through SPSS V.22. Again the measure for the sampling adequacy test and the Bartlett test of sphericity should be performed in each run of factor analysis. On the basis of results obtained, it can be deemed fit to proceed with conducting the principle factor analysis using the remaining variables in each run. For this part of study, the results of the final run test revealed that all the remaining variables had good sample adequacy. In final, 28 items remained in the accepted solution and the KMO test gave the value of 0.73 and the Bartlett test of sphericity reached statistical significance with (Chi-square 1209.36) and significance level of (p-value 0.00).

On the basis of the results of the several tests on the 31 barriers for energy management adoption which revealed that all the 31 variables should be retained in the first run. After performing factor extraction and rotation on these 31 variables, other criteria for factor analysis may justify the elimination of any variable from the proposed list before moving to the next run. The sections provided later can describe how factor analysis and data validation processed for the 31 barriers in this study.

***Second phase of factor analysis for energy management adoption barriers: Factors extraction***

After all the appropriate checks were performed and indicated that all the 31 variables should be retained in an initial capture of factors, using the principal component analysis approach with exploratory factor analysis through SPSS v.22. First step undertaken was to decide how many factors are to be extracted from the given set of data. Therefore, factor solution without rotation were computed. The Kaiser's criterion was used with eigenvalues equal to or greater than unity, in order to establish the number of extraction factors (Tabachnick and Fidell, 2007). Scree plot was used only to validate the number of the extracted factor generated from Kaiser's criterion. This exercise revealed the presence of six distinct factors when performing the first run of factor analysis which involved all the 31 barriers. To obtain interpretable results for those six factors, a Varimax rotation was then performed. Varimax rotation minimizes the number of variables that have high loadings on any one given factor. Several criteria should be achieved in order to accept the extracted solution obtained in any phase and to consider this solution as an suitable final solution for the involved variables. The following sections explains these criteria and process of investigation.

1. **Communality values**

Communality is the first criteria to be checked in the extracted solution. It reveals the percentage of variance in a particular variable that is explained by the factor (Williams et al., 2010). Larose (2006) has also claimed that communalities less than 0.5 were considered too low, since this would meant that the variable shares less than half of its variability with other variables. Higher communality value means higher importance of the variable. Table (4.22) depicts the results of communality values for the extracted solutions in the first run and the final run (fourth run) of factor analysis processed on the barriers for energy management. The general guidelines mentioned that the factor solution explain at least half of each original variable's variance, thus the communality value (score after extraction) should be more than 0.5 point for the data to be justifiable for accepting the factor analysis solution. In the first run, the analysis revealed that the values of the extracted communalities for all variables (barriers) were higher than 0.5. Accordingly, this set of data input can be considered justifiable for the application of factor analysis method. In addition, each time in which the data changed, this test should be repeated to check the extracted communality values. Therefore, variables with communalities less than 0.5 were suppressed and removed from the analysis due to a low communality. As shown in Table (4.22), the final run communality values confirms with this assumption as their values larger than 0.5.

Table (4.19): Correlation matrix for energy management adoption barriers

| | BEM 1 | BEM 2 | BEM 3 | BEM 4 | BEM 5 | BEM 6 | BEM 7 | BEM 8 | BEM 9 | BEM 10 | BEM 11 | BEM 12 | BEM 13 | BEM 14 | BEM 15 | BEM 16 | BEM 17 | BEM 18 | BEM 19 | BEM 20 | BEM 21 | BEM 22 | BEM 23 | BEM 24 | BEM 25 | BEM 26 | BEM 27 | BEM 28 | BEM 29 | BEM 30 | BEM 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BEM1 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| BEM2 | -0.07 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| BEM3 | **0.62** | 0.14 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| BEM4 | **0.70** | -0.09 | **0.63** | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| BEM5 | **0.55** | 0.08 | **0.59** | **0.51** | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | |
| BEM6 | 0.09 | -0.21 | 0.22 | 0.13 | 0.25 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | |
| BEM7 | -0.02 | **0.37** | 0.14 | -0.01 | 0.17 | 0.00 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | |
| BEM8 | -0.03 | -0.28 | 0.05 | 0.08 | 0.07 | 0.00 | -0.09 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | |
| BEM9 | **0.78** | -0.08 | **0.65** | **0.74** | **0.54** | 0.13 | -0.06 | 0.00 | 1.00 | | | | | | | | | | | | | | | | | | | | | | |
| BEM10 | 0.07 | **0.46** | **0.25** | 0.03 | 0.06 | -0.13 | **0.45** | -0.20 | -0.02 | 1.00 | | | | | | | | | | | | | | | | | | | | | |
| BEM11 | 0.07 | **0.47** | 0.18 | 0.15 | 0.16 | -0.21 | **0.52** | 0.12 | 0.05 | **0.43** | 1.00 | | | | | | | | | | | | | | | | | | | | |
| BEM12 | 0.19 | -0.11 | 0.17 | 0.06 | 0.11 | **0.42** | -0.13 | 0.07 | 0.11 | **-0.31** | -0.12 | 1.00 | | | | | | | | | | | | | | | | | | | |
| BEM13 | 0.07 | **0.33** | 0.13 | 0.06 | 0.09 | -0.03 | **0.52** | 0.01 | 0.05 | **0.48** | **0.42** | -0.11 | 1.00 | | | | | | | | | | | | | | | | | | |
| BEM14 | -0.07 | **0.38** | 0.17 | 0.04 | 0.01 | -0.13 | **0.40** | 0.11 | -0.03 | **0.41** | **0.36** | -0.08 | **0.40** | 1.00 | | | | | | | | | | | | | | | | | |
| BEM15 | **0.58** | 0.01 | **0.51** | **0.65** | **0.53** | 0.10 | -0.01 | 0.06 | **0.71** | -0.07 | -0.03 | -0.06 | 0.01 | 0.04 | 1.00 | | | | | | | | | | | | | | | | |
| BEM16 | 0.05 | **0.30** | 0.24 | 0.06 | 0.03 | 0.07 | **0.49** | -0.16 | -0.07 | **0.48** | **0.34** | -0.07 | **0.41** | **0.45** | -0.06 | 1.00 | | | | | | | | | | | | | | | |
| BEM17 | 0.05 | **0.57** | 0.22 | 0.08 | -0.01 | -0.07 | **0.32** | -0.22 | 0.03 | **0.43** | **0.40** | -0.02 | **0.44** | **0.42** | 0.01 | 0.36 | 1.00 | | | | | | | | | | | | | | |
| BEM18 | -0.09 | -0.08 | -0.01 | -0.12 | 0.09 | 0.03 | 0.04 | **0.43** | -0.05 | -0.05 | 0.13 | 0.05 | 0.07 | 0.10 | -0.03 | -0.05 | -0.09 | 1.00 | | | | | | | | | | | | | |
| BEM19 | -0.10 | -0.09 | -0.06 | -0.09 | 0.04 | 0.14 | -0.04 | **0.47** | -0.15 | -0.02 | 0.01 | 0.07 | 0.00 | -0.06 | -0.02 | -0.19 | -0.15 | **0.53** | 1.00 | | | | | | | | | | | | |
| BEM20 | -0.05 | 0.03 | -0.05 | -0.04 | 0.16 | 0.03 | 0.02 | **0.42** | -0.13 | -0.14 | 0.03 | 0.02 | 0.14 | -0.02 | 0.14 | -0.16 | -0.16 | **0.45** | 0.64 | 1.00 | | | | | | | | | | | |
| BEM21 | 0.04 | -0.17 | 0.17 | 0.08 | 0.18 | -0.06 | -0.06 | **0.45** | 0.06 | -0.13 | 0.15 | 0.02 | 0.03 | -0.11 | 0.05 | -0.16 | -0.16 | **0.64** | 0.50 | **0.38** | 1.00 | | | | | | | | | | |
| BEM22 | 0.08 | **0.34** | 0.29 | 0.09 | 0.14 | 0.03 | **0.54** | -0.12 | -0.03 | **0.53** | **0.39** | -0.06 | **0.46** | **0.37** | -0.04 | **0.57** | **0.54** | -0.09 | -0.18 | -0.10 | -0.16 | 1.00 | | | | | | | | | |
| BEM23 | -0.20 | -0.02 | -0.07 | -0.16 | 0.08 | 0.01 | 0.10 | **0.49** | -0.20 | -0.09 | 0.17 | -0.07 | 0.05 | -0.02 | -0.09 | -0.13 | -0.22 | **0.46** | **0.70** | **0.50** | **0.53** | -0.19 | 1.00 | | | | | | | | |
| BEM24 | -0.12 | -0.08 | -0.02 | -0.09 | -0.03 | 0.06 | 0.03 | **0.40** | -0.12 | -0.11 | 0.04 | 0.05 | 0.03 | -0.09 | -0.02 | -0.20 | -0.22 | **0.50** | **0.68** | **0.54** | **0.42** | -0.20 | **0.70** | 1.00 | | | | | | | |
| BEM25 | -0.08 | 0.08 | 0.02 | -0.13 | 0.03 | -0.09 | -0.02 | **0.52** | -0.10 | -0.21 | 0.14 | 0.07 | 0.06 | 0.09 | 0.04 | -0.15 | -0.05 | **0.47** | **0.37** | **0.58** | **0.47** | -0.08 | **0.39** | **0.37** | 1.00 | | | | | | |
| BEM26 | 0.12 | -0.08 | 0.02 | 0.01 | 0.12 | **0.42** | -0.10 | 0.07 | 0.05 | -0.23 | -0.08 | **0.59** | -0.10 | -0.26 | -0.05 | -0.10 | -0.07 | 0.10 | 0.15 | 0.10 | 0.03 | -0.04 | 0.04 | 0.16 | 0.12 | 1.00 | | | | | |
| BEM27 | 0.15 | -0.04 | 0.12 | 0.11 | 0.15 | **0.47** | -0.08 | 0.12 | 0.19 | **-0.30** | -0.05 | **0.55** | -0.15 | -0.13 | 0.15 | -0.08 | -0.12 | 0.10 | 0.11 | 0.16 | 0.07 | 0.00 | 0.10 | 0.18 | 0.14 | **0.72** | 1.00 | | | | |
| BEM28 | 0.11 | 0.03 | 0.16 | 0.19 | 0.15 | **0.58** | 0.03 | 0.00 | 0.13 | -0.16 | 0.03 | **0.52** | -0.03 | -0.10 | 0.08 | 0.09 | -0.09 | 0.09 | 0.16 | 0.16 | 0.01 | 0.15 | 0.07 | 0.16 | 0.05 | **0.46** | **0.60** | 1.00 | | | |
| BEM29 | 0.12 | -0.08 | 0.15 | 0.14 | 0.15 | **0.42** | -0.01 | 0.06 | 0.07 | -0.22 | 0.00 | **0.59** | -0.09 | -0.23 | -0.04 | 0.02 | -0.10 | 0.04 | 0.19 | 0.12 | 0.00 | 0.07 | 0.07 | 0.21 | -0.01 | **0.62** | **0.54** | **0.55** | 1.00 | | |
| BEM30 | 0.13 | -0.20 | 0.13 | 0.17 | 0.11 | **0.59** | 0.03 | -0.10 | 0.13 | -0.11 | -0.17 | **0.49** | -0.14 | -0.10 | 0.01 | 0.11 | -0.15 | 0.02 | 0.13 | 0.00 | -0.04 | 0.05 | -0.07 | 0.10 | -0.12 | **0.47** | **0.52** | **0.59** | **0.57** | 1.00 | |
| BEM31 | -0.05 | 0.00 | 0.16 | 0.19 | 0.12 | **0.42** | 0.04 | 0.05 | 0.07 | -0.22 | 0.03 | **0.50** | 0.04 | -0.12 | 0.02 | 0.03 | -0.12 | 0.07 | -0.01 | 0.00 | 0.01 | 0.13 | 0.00 | 0.15 | 0.01 | **0.44** | **0.51** | **0.64** | **0.58** | **0.52** | 1.00 |

Table (4.20): Anti-image correlation matrix for energy management adoption barriers

| | BEM 1 | BEM 2 | BEM 3 | BEM 4 | BEM 5 | BEM 6 | BEM 7 | BEM 8 | BEM 9 | BEM 10 | BEM 11 | BEM 12 | BEM 13 | BEM 14 | BEM 15 | BEM 16 | BEM 17 | BEM 18 | BEM 19 | BEM 20 | BEM 21 | BEM 22 | BEM 23 | BEM 24 | BEM 25 | BEM 26 | BEM 27 | BEM 28 | BEM 29 | BEM 30 | BEM 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BEM1 | **0.76**[a] | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| BEM2 | 0.04 | **0.61**[a] | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| BEM3 | -0.15 | -0.14 | **0.67**[a] | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| BEM4 | -0.33 | 0.24 | -0.13 | **0.74**[a] | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| BEM5 | -0.17 | -0.21 | -0.18 | -0.04 | **0.71**[a] | | | | | | | | | | | | | | | | | | | | | | | | | | |
| BEM6 | 0.18 | 0.31 | -0.30 | 0.07 | -0.28 | **0.68**[a] | | | | | | | | | | | | | | | | | | | | | | | | | |
| BEM7 | 0.04 | -0.06 | 0.03 | 0.10 | -0.08 | -0.08 | **0.80**[a] | | | | | | | | | | | | | | | | | | | | | | | | |
| BEM8 | 0.08 | 0.33 | -0.04 | -0.14 | 0.04 | -0.05 | 0.12 | **0.76**[a] | | | | | | | | | | | | | | | | | | | | | | | |
| BEM9 | -0.30 | 0.05 | -0.37 | -0.17 | -0.07 | 0.14 | 0.02 | -0.01 | **0.73**[a] | | | | | | | | | | | | | | | | | | | | | | |
| BEM10 | -0.02 | -0.27 | -0.34 | 0.01 | 0.08 | 0.01 | 0.05 | 0.04 | 0.14 | **0.72**[a] | | | | | | | | | | | | | | | | | | | | | |
| BEM11 | -0.04 | -0.19 | 0.21 | -0.20 | -0.09 | 0.12 | -0.33 | -0.22 | -0.12 | -0.25 | **0.73**[a] | | | | | | | | | | | | | | | | | | | | |
| BEM12 | -0.30 | 0.11 | -0.17 | 0.26 | -0.05 | 0.04 | -0.04 | -0.10 | 0.09 | 0.16 | 0.06 | **0.76**[a] | | | | | | | | | | | | | | | | | | | |
| BEM13 | -0.16 | 0.06 | 0.36 | 0.10 | 0.07 | -0.22 | -0.22 | 0.00 | -0.34 | -0.32 | 0.08 | -0.01 | **0.58**[a] | | | | | | | | | | | | | | | | | | |
| BEM14 | 0.27 | -0.14 | -0.15 | -0.19 | -0.03 | 0.15 | -0.09 | -0.22 | 0.08 | -0.03 | -0.03 | -0.24 | -0.23 | **0.65**[a] | | | | | | | | | | | | | | | | | |
| BEM15 | -0.03 | -0.09 | 0.05 | -0.24 | -0.19 | -0.05 | -0.15 | -0.01 | -0.35 | 0.05 | 0.24 | 0.17 | 0.13 | -0.06 | **0.78**[a] | | | | | | | | | | | | | | | | |
| BEM16 | -0.13 | -0.03 | -0.22 | -0.02 | 0.16 | -0.04 | -0.08 | 0.03 | 0.28 | 0.00 | -0.09 | 0.09 | -0.18 | -0.18 | -0.09 | **0.81**[a] | | | | | | | | | | | | | | | |
| BEM17 | 0.14 | -0.47 | -0.09 | -0.23 | 0.24 | -0.21 | 0.15 | 0.13 | 0.02 | 0.23 | -0.19 | -0.24 | -0.25 | -0.02 | -0.06 | 0.08 | **0.63**[a] | | | | | | | | | | | | | | |
| BEM18 | -0.06 | 0.12 | 0.23 | 0.25 | -0.11 | -0.08 | -0.02 | -0.04 | -0.23 | -0.11 | 0.02 | 0.08 | 0.21 | -0.29 | 0.08 | -0.15 | -0.13 | **0.69**[a] | | | | | | | | | | | | | |
| BEM19 | -0.08 | -0.07 | 0.18 | 0.01 | 0.12 | -0.15 | 0.07 | -0.21 | -0.04 | -0.29 | 0.15 | -0.07 | 0.18 | -0.06 | -0.07 | 0.10 | -0.14 | -0.06 | **0.75**[a] | | | | | | | | | | | | |
| BEM20 | 0.06 | -0.10 | -0.03 | -0.16 | -0.24 | 0.12 | 0.02 | -0.01 | 0.31 | 0.15 | 0.04 | 0.01 | -0.37 | 0.15 | -0.18 | 0.06 | 0.16 | -0.15 | -0.39 | **0.67**[a] | | | | | | | | | | | |
| BEM21 | 0.14 | 0.16 | -0.37 | -0.16 | -0.07 | 0.25 | 0.05 | 0.06 | 0.16 | 0.12 | -0.17 | -0.06 | -0.25 | 0.33 | 0.03 | 0.05 | 0.03 | -0.51 | -0.23 | 0.16 | **0.64**[a] | | | | | | | | | | |
| BEM22 | -0.09 | 0.30 | -0.17 | 0.12 | -0.21 | 0.24 | -0.30 | -0.12 | 0.18 | -0.26 | 0.08 | 0.27 | -0.06 | 0.01 | 0.08 | -0.16 | -0.47 | 0.05 | 0.00 | -0.01 | 0.07 | **0.68**[a] | | | | | | | | | |
| BEM23 | 0.09 | -0.06 | -0.02 | 0.04 | -0.27 | 0.01 | -0.15 | -0.16 | 0.07 | 0.14 | -0.09 | 0.13 | -0.08 | 0.01 | 0.12 | -0.09 | 0.09 | 0.13 | -0.39 | 0.15 | -0.18 | 0.13 | **0.77**[a] | | | | | | | | |
| BEM24 | -0.04 | 0.09 | -0.25 | 0.04 | 0.25 | 0.13 | -0.08 | 0.04 | 0.08 | 0.00 | -0.02 | 0.09 | -0.09 | 0.07 | -0.08 | 0.15 | -0.01 | -0.24 | -0.18 | -0.13 | 0.18 | 0.11 | -0.41 | **0.80**[a] | | | | | | | |
| BEM25 | -0.08 | -0.21 | -0.15 | 0.20 | 0.17 | 0.01 | 0.04 | -0.32 | 0.03 | 0.24 | -0.10 | 0.02 | 0.00 | -0.09 | -0.07 | 0.08 | 0.03 | -0.07 | 0.14 | -0.37 | -0.21 | -0.08 | 0.01 | 0.01 | **0.73**[a] | | | | | | |
| BEM26 | -0.06 | 0.04 | 0.11 | -0.04 | -0.20 | -0.01 | -0.01 | -0.01 | 0.09 | -0.13 | 0.04 | -0.15 | -0.09 | 0.24 | 0.11 | -0.02 | -0.11 | -0.09 | -0.09 | 0.16 | 0.12 | 0.12 | 0.10 | -0.03 | -0.20 | **0.77**[a] | | | | | |
| BEM27 | -0.08 | -0.14 | 0.11 | 0.17 | 0.21 | -0.19 | 0.09 | -0.07 | -0.19 | 0.06 | -0.05 | -0.06 | 0.22 | -0.21 | -0.18 | 0.05 | 0.06 | 0.10 | 0.26 | -0.21 | -0.19 | -0.19 | -0.20 | -0.03 | 0.12 | -0.56 | **0.74**[a] | | | | |
| BEM28 | -0.02 | -0.23 | 0.14 | -0.15 | 0.18 | -0.39 | 0.12 | 0.16 | -0.12 | 0.06 | -0.13 | -0.22 | 0.09 | 0.05 | 0.03 | -0.09 | 0.23 | -0.04 | -0.06 | -0.13 | 0.02 | -0.29 | -0.10 | 0.02 | -0.03 | 0.07 | -0.12 | **0.79**[a] | | | |
| BEM29 | 0.04 | -0.05 | -0.14 | -0.07 | 0.01 | 0.04 | 0.01 | -0.02 | 0.03 | 0.19 | -0.15 | -0.22 | 0.00 | 0.17 | 0.08 | -0.07 | 0.09 | 0.02 | -0.14 | -0.07 | 0.13 | -0.13 | 0.02 | -0.07 | 0.15 | -0.27 | 0.02 | 0.01 | **0.86**[a] | | |
| BEM30 | -0.04 | 0.18 | 0.18 | -0.06 | -0.01 | -0.24 | -0.18 | 0.22 | -0.14 | -0.18 | 0.14 | -0.05 | 0.25 | -0.18 | 0.14 | -0.17 | 0.00 | 0.12 | -0.16 | -0.02 | -0.12 | 0.05 | 0.15 | -0.09 | -0.06 | 0.01 | -0.13 | -0.09 | -0.19 | **0.79**[a] | |
| BEM31 | 0.41 | -0.21 | -0.18 | -0.32 | -0.04 | 0.07 | 0.04 | -0.08 | 0.14 | 0.22 | -0.04 | -0.21 | -0.37 | 0.23 | -0.07 | 0.11 | 0.29 | -0.22 | 0.08 | 0.27 | 0.12 | -0.16 | 0.10 | -0.14 | 0.00 | 0.01 | -0.11 | -0.24 | -0.12 | -0.22 | **0.66**[a] |

a. Measures of Sampling Adequacy(MSA)

Table (4.21): KMO and Bartlett's test for energy management adoption barriers

| KMO and Bartlett's Test | | | |
|---|---|---|---|
| Item | | Factor analysis run description | |
| | | First Run | Final Run ” Forth run” |
| Number of included variables | | 31 | 28 |
| Number of extracted factors | | 6 | 5 |
| Kaiser-Meyer-Olkin Measure of Sampling Adequacy. | | 0.72 | 0.73 |
| Bartlett's Test of Sphericity | Approx. Chi-Square | 1385.59 | 1209.36 |
| | df | 465 | 378 |
| | Sig. | 0.00 | 0.00 |
| Cronbach's alpha | | 0.81 | 0.81 |

**2. Cumulative percentage of variance explained by the extracted factor solution.**

Total variance explained table is one of the main results of factor analysis by which the suitability of the extracted solution can be decided on the basis of the commutative variance explained and the number of the significant factors can be determined on eigenvalue basis. Table (4.23) shows the first run total variance explained by all variables under the barriers for energy management adoption. Typically, the percent of commutative variance explained by an acceptable solution should not be less than 50%, which are generally considered necessary for practical significance (Meyers et al., 2006). The results shows that six factors shoud be extracted as there were six components with eigenvalue greater than one as proposed by Byrne (2010) and Hair et al. (2010). The cumulative percentage of variance explained by these six factors was 66.92%, meaning that a considerable amount of the common variance shared by the 31 variables could be accounted for by these six factors (De Vaus, 2002). This value considered acceptable for forward discussion because it is larger than 50% (Meyers et al., 2006; Mane and Nagesha, 2014). The components solution explained a sum of the variance with component 1 contributing of 15.72%, component 2 contributing of 14.46%, component 3 contributing of 14.35%, component 4 contributing of 13.47%, component 5 contributing of 4.55% and component 6 with 4.38. Thus, the first component is the most important factor as it explains the most variance of the data. Total variance explained by the final run of factor analysis on energy management barriers was 65.33% and including four factors as shown in Table (E.7) in appendix E.

Table (4.22) : Communality values of energy management adoption barriers "First run & Final run"

| Item | Extraction | |
|---|---|---|
| | First Run | Final Run "Fourth run" |
| BEM1 | 0.74 | 0.74 |
| BEM2 | 0.82 | Removed in 2ed run |
| BEM3 | 0.71 | 0.70 |
| BEM4 | 0.76 | 0.74 |
| BEM5 | 0.60 | 0.59 |
| BEM6 | 0.59 | 0.65 |
| BEM7 | 0.61 | 0.62 |
| BEM8 | 0.70 | 0.53 |
| BEM9 | 0.83 | 0.84 |
| BEM10 | 0.68 | 0.64 |
| BEM11 | 0.55 | 0.66 |
| BEM12 | 0.68 | 0.68 |
| BEM13 | 0.51 | 0.54 |
| BEM14 | 0.57 | Removed in 3ed run |
| BEM15 | 0.69 | 0.71 |
| BEM16 | 0.66 | 0.59 |
| BEM17 | 0.62 | 0.54 |
| BEM18 | 0.60 | 0.56 |
| BEM19 | 0.76 | 0.75 |
| BEM20 | 0.63 | 0.57 |
| BEM21 | 0.61 | 0.61 |
| BEM22 | 0.66 | 0.69 |
| BEM23 | 0.75 | 0.73 |
| BEM24 | 0.70 | 0.67 |
| BEM25 | 0.72 | Removed in the 4th run |
| BEM26 | 0.67 | 0.66 |
| BEM27 | 0.70 | 0.67 |
| BEM28 | 0.67 | 0.68 |
| BEM29 | 0.66 | 0.66 |
| BEM30 | 0.71 | 0.71 |
| BEM31 | 0.58 | 0.58 |

*Extraction Method: Principal Component Analysis.*
*Items were removed during several runs of factor analysis*

Table (4.23): Total variance explained by factor analysis for the first run of the barriers for energy management adoption

| Component | Initial Eigenvalues | | | Extraction Sums of Squared Loadings | | | Rotation Sums of Squared Loadings | | |
|---|---|---|---|---|---|---|---|---|---|
| | Total | % of Variance | Cumulative % | Total | % of Variance | Cumulative % | Total | % of Variance | Cumulative % |
| 1 | 5.76 | 18.58 | 18.58 | 5.76 | 18.58 | 18.58 | 4.87 | 15.72 | 15.72 |
| 2 | 5.00 | 16.13 | 34.71 | 5.00 | 16.13 | 34.71 | 4.48 | 14.46 | 30.18 |
| 3 | 4.24 | 13.68 | 48.39 | 4.24 | 13.68 | 48.39 | 4.45 | 14.35 | 44.53 |
| 4 | 3.40 | 10.98 | 59.37 | 3.40 | 10.98 | 59.37 | 4.17 | 13.47 | 57.99 |
| 5 | 1.27 | 4.10 | 63.48 | 1.27 | 4.10 | 63.48 | 1.41 | 4.55 | 62.54 |
| 6 | 1.07 | 3.45 | 66.92 | 1.07 | 3.45 | 66.92 | 1.36 | 4.38 | 66.92 |
| 7 | 0.94 | 3.05 | 69.97 | | | | | | |
| 8 | 0.88 | 2.84 | 72.81 | | | | | | |
| 9 | 0.75 | 2.43 | 75.24 | | | | | | |
| 10 | 0.75 | 2.42 | 77.66 | | | | | | |
| 11 | 0.68 | 2.20 | 79.86 | | | | | | |
| 12 | 0.63 | 2.04 | 81.90 | | | | | | |
| 13 | 0.60 | 1.94 | 83.84 | | | | | | |
| 14 | 0.55 | 1.79 | 85.63 | | | | | | |
| 15 | 0.50 | 1.60 | 87.23 | | | | | | |
| 16 | 0.46 | 1.49 | 88.72 | | | | | | |
| 17 | 0.46 | 1.49 | 90.21 | | | | | | |
| 18 | 0.42 | 1.35 | 91.55 | | | | | | |
| 19 | 0.37 | 1.19 | 92.74 | | | | | | |
| 20 | 0.35 | 1.13 | 93.88 | | | | | | |
| 21 | 0.28 | 0.89 | 94.77 | | | | | | |
| 22 | 0.25 | 0.82 | 95.59 | | | | | | |
| 23 | 0.25 | 0.79 | 96.39 | | | | | | |
| 24 | 0.22 | 0.70 | 97.08 | | | | | | |
| 25 | 0.19 | 0.60 | 97.69 | | | | | | |
| 26 | 0.15 | 0.50 | 98.18 | | | | | | |
| 27 | 0.15 | 0.47 | 98.65 | | | | | | |
| 28 | 0.14 | 0.44 | 99.10 | | | | | | |
| 29 | 0.11 | 0.35 | 99.44 | | | | | | |
| 30 | 0.10 | 0.31 | 99.75 | | | | | | |
| 31 | 0.08 | 0.25 | 100.00 | | | | | | |

Extraction Method: Principal Component Analysis

3. **Loaded items and extracted factors properties.**

The result of applying rotation method of Varimax with Kaiser normalization in the first run showed that the 31 energy management adoption barriers can be represented by six components in each one of these components some correlated variables are involved. For practical significance, factor loadings were restricted to 0.50 and above (Hair et al., 2010; Mane and Nagesha, 2014). On the basis of such restriction, six items loaded on the first factor, eight items loaded on the second factor, nine items loaded on the third factor, six items loaded on the fourth factor, two items loaded on the fifth factor and one item only loaded on the sixth item “Table (4.23)”. It is worth noting here, that rotated component matrix table should be checked only after satisfying all requirements mentioned above such as MSA values, communalities, KMO, p-value for Bartlett’s test of sphericity and etc.,. So that, the first run rotated component matrix table provided here for clarification only about the procedures to be followed to accept the created solution. However, three conditions should be satisfied in this table to consider the solution acceptable. The first run results “ Table (4.23)” have been used here to check the three conditions, as follows:

**<u>First condition:</u> Each item should has at least one factor loading value equal or more than (0.5).**

This condition requires the items with factor loading equal or more than 0.5 to be included in the acceptable solution and any item from this solution should have at least one factor loading value equal or more than 0.5 to be remained in further analysis. So that, any item haven’t at least one factor loading equal or more than 0.5 should be removed from analysis (Hair et al., 2010; Mane and Nagesha, 2014). On the basis of this requirement, any factor loading value less than 0.5 was blanked and didn’t appeared in Table (4.24). Therefore, only factor loadings equal or more than 0.5 are shown in this table. Accordingly, each one of the 31 items (barriers) involved in the first run had at least one factor loading greater than 0.5 which revealed that each one of these items can be loaded at least on one factor of the extracted factors. Hence, all the 31 items (barriers) satisfied this condition and should be remained in further analysis on the basis of this requirement if other requirements of factor analysis satisfied.

**<u>Second condition:</u> Each one of the extracted factors should include at least three items to be acceptable.**

By this condition on the extracted factors, each factor from the extracted factors should have at least 3 items, when the factor doesn’t satisfy this requirement it should be removed from analysis by removing the involved items. So that, the factors extracted from the first run were examined to identify the number of items that loaded on each factor by keeping in mind the rule for not selecting factors with fewer than three items because it is generally weak and unstable (Costello and Osborne, 2005). Table (4.24) stipulates that two extracted factors from the first run involved less than three item which were:

- The fifth factor with only two items (barriers) which were *BEM8 and BEM25*.
- The sixth factor with only one item (barrier) which was *BEM2*.

On the basis of such results, it was deemed to remove the sixth factor by omitting *BEM2* which was the only item loaded on it. The sixth factor with one item alone was weaker than the fifth factor that involving two items. Henson and Roberts (2006) reported that a factor with lower number of variables is weaker than factor with more items. Additionally, the percent of variance explained by the sixth factor (4.38%) less than percent explained by the fifth factor (4.55%) as shown by Table (4.24). This result supports the priority of the sixth factor for removal.

**<u>Third condition:</u> The item loaded on more than one factor with factor loading greater than 0.5 should be removed "no cross-loading items".**

Cross loaded item that has significant loading factor value equal or more than 0.5 and loaded on more than one factor. De Vaus (2002) concluded that, cross-loading item become a candidate for deletion from the analysis. In Table (4.24), it worth noting that, three items have been loaded on more than one factor with a factor loading larger than 0.5, which known as cross-loading variable (Hair et al., 2010). These three cross-loading variables including the following :

- The item (barrier) *BEM25* loaded on the second and the fifth factors by factor loadings of 0.54 and 0.59, respectively.
- Item (barrier) *BEM8* loaded on the second and the fifth factors by factor loadings of 0.56 and 0.58, respectively.
- The item (barrier) *BEM2* has been loaded on the third factor and sixth factor with factor loadings of 0.52 and 0.72, respectively.

Therefore, the item *BEM2* eliminated from analysis and the extracted factors were then examined for the remaining data adequacy and strength requirements as mentioned in the previous discussion.

Several repetitions have been performed till obtaining acceptable final solution satisfied all factor analysis requirements. In general, four runs were conducted on the barriers involved in study questionnaire. The first run was performed with the 31 barriers included in study. In each run after the first run, one item (barrier) at least removed from analysis because it violated one or more of factor analysis requirements. Three items (barriers) were removed for different reasons as follows :

1- *BEM2* has been removed in the second run as it was the only variable loaded on the sixth factor extracted from solution. Additionally this barrier (item) is a cross-loading item because it was loaded on two factors in the first run by factor loadings more than 0.5. Existence of this item in the weaker factor from the extracted factors can be considered as another reason justified this item deletion.

2- In the third run, the item *BEM14* was removed because its communality value less than 0.5.

3- The fourth run was completed without the item *BEM25* because it was the only factor loaded on the fifth factor extracted in this run.

Table (4.24): Rotated component matrix for the first run of energy management adoption barriers.

| Item | Component | | | | | |
|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 |
| BEM28 | 0.80 | | | | | |
| BEM29 | 0.80 | | | | | |
| BEM27 | 0.79 | | | | | |
| BEM26 | 0.77 | | | | | |
| BEM12 | 0.76 | | | | | |
| BEM31 | 0.75 | | | | | |
| BEM30 | 0.75 | | | | | |
| BEM6 | 0.67 | | | | | |
| BEM19 | | 0.86 | | | | |
| BEM23 | | 0.86 | | | | |
| BEM24 | | 0.81 | | | | |
| BEM20 | | 0.76 | | | | |
| BEM18 | | 0.67 | | | | |
| BEM21 | | 0.66 | | | | |
| BEM22 | | | 0.78 | | | |
| BEM16 | | | 0.76 | | | |
| BEM7 | | | 0.75 | | | |
| BEM10 | | | 0.72 | | | |
| BEM13 | | | 0.69 | | | |
| BEM14 | | | 0.66 | | | |
| BEM11 | | | 0.64 | | | |
| BEM17 | | | 0.60 | | | |
| BEM9 | | | | 0.90 | | |
| BEM1 | | | | 0.85 | | |
| BEM4 | | | | 0.85 | | |
| BEM15 | | | | 0.82 | | |
| BEM3 | | | | 0.77 | | |
| BEM5 | | | | 0.73 | | |
| BEM25 | | 0.54 | | | 0.59 | |
| BEM8 | | 0.56 | | | 0.58 | |
| BEM2 | | | 0.52 | | | 0.72 |

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

Finally, all factor analysis results satisfied the factor analysis requirements as discussed previously and it can be considered as the final solution to be accepted and interpreted. As shown in Table (4.21), the reduced data set of 28 variables (barriers) resulted in a Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy of 0.73, which is considered as satisfactory. Another mode of determining the appropriateness of factor analysis, the Bartlett test of sphericity, reached statistical significance with (Chi-square= 1209.36) and significance level of (p-value = 0.000) which was lower than 0.05. In addition, all other requirements of factor analysis were satisfied in the final solution as described here:

1. The correlation matrix of the remaining variables involved several correlation coefficients between 0.3-0.9 without any value larger than 0.9 as shown in Table (E.5) in appendix E.
2. All values of the measure for sampling adequacy have been larger than 0.5 as shown in the anti-image correlation matrix presented in Table (E.6) of appendix E.
3. Communalities of the remaining items displayed in Table (4.22) were larger than 0.5.
4. Commutative variance of the four factor extracted in the fourth (final) run was 62.88% which was larger than 50 % as required, and shown in Table (E.7) of appendix E.
5. Table (E.8) in Appendix E displayed that each one of the four factors extracted in the fourth run had more than two items loaded on it with factor loading more than 0.5 ( for example, the first factor included eight items loaded with factor loading more than 0.5) and without any cross-loading item. In addition, the commutative percent of variance explained by this solution is larger than 50%.

Therefore, the fourth run of factor analysis was deemed appropriate for discussion and interpretation in the barriers of energy management adoption in local construction sector. This analysis yielded four components extracted with eigenvalues exceeding one, and only those items which have got a factor loading equal to or more than 0.5 appeared in each component (factor). Scree plot for the final repetition of factor analysis has presented in Figure (4.7) below. From this figure, at eigenvalue equals to one on the vertical axis, it is clear that a break after the fourth component in the final solution.

This four factor solution accounted for 62.88% of the total variance in the 28 barriers for energy management adoption. Table (4.25) shows that, the four components solution explained a sum of the variance with the first component (factor) involved eight items and contributing 18.24%; second component involved seven item and contributing 15.80%; third component involved six items contributing 14.98% and the fourth component involved seven items contributing 13.86%. Table (4.25) below summarizes the results and actions taken in every run of factor analysis for the barriers of energy management to get the final solution.

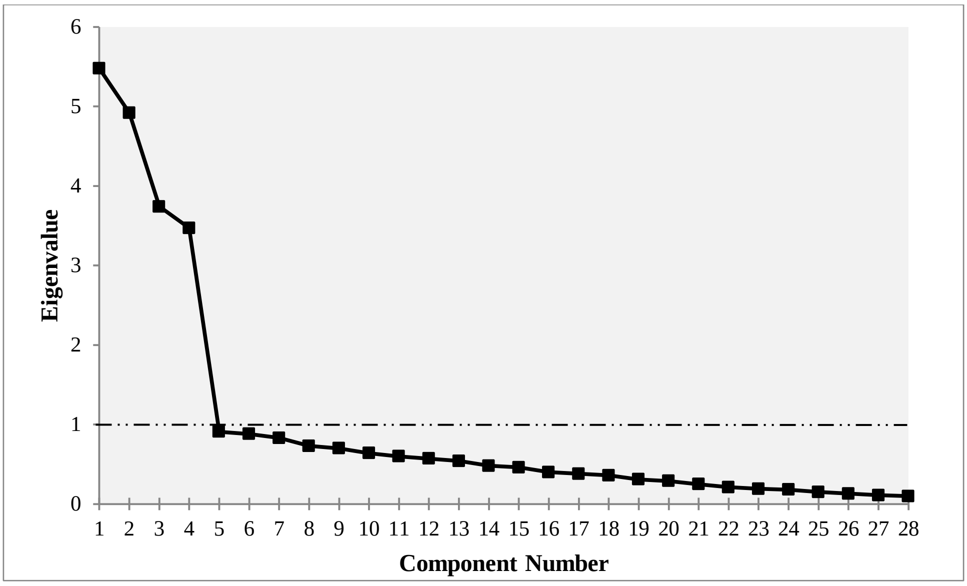


Figure (4.7): Scree plot of the final run of energy management adoption barriers

**4. Reliability measure of the extracted factors.**

The final solution obtained in the fourth run of factor analyses was subjected to reliability analysis by using Cronbach's Alpha (Cα) coefficient to check if this model with four factors adequately represents the data. Cronbach's Alpha (Cα) value for the 28 items (barriers) remaining in the final solution equals to 0.81. The reliability scores (Cronbach's α) were also calculated for individual factors. Each factor of the final four factors solution, were subjected to reliability analysis based on the variables loaded on its, as shown it Table (4.26) below. The value of Cronbach's α for the first, second, third and fourth factors was 0.9, 0.88 , 0.91, and 0.85, respectively. All values of Cronbach's α for all data and for each factor have been larger than 0.7, indicating adequate internal consistency according to Pallant (2005).

Table (4.26) demonstrates the 28 remaining variables (barriers) in four factors, and their respective factor loadings, explained variances, eigenvalues and Cornbach's α for each of the four factors. This table was prepared in the descending order with the topmost factor at the beginning and the items in each factor where arranged in descending order according to its importance based on its loading values in the factor contained it.

Table (4.25): Factor analysis runs and related data of energy management adoption barriers

| Requirement | Requirement threshold | Run number | | | |
|---|---|---|---|---|---|
| | | First | Second | Third | Fourth |
| Reliability of remaining variables | Cα > 0.7 | 0.81 | 0.81 | 0.81 | 0.81 |
| MSA values check for each variable | > 0.5 | Satisfied | Satisfied | Satisfied | Satisfied |
| KMO index | > 0.5 | 0.72 | 0.73 | 0.74 | 0.73 |
| Bartlett's test of sphericity "Sig" | < 0.05 | 0.00 | 0.00 | 0.00 | 0.00 |
| Communality values | > 0.5 | Satisfied | Satisfied except; ▪ BEM14 = 0.495, | Satisfied | Satisfied |
| Cumulative % of variance explained | > 50% | 66.92 % | 64.10% | 64.91% | 62.88% |
| No. of variables in each extracted factor | > 2 | Satisfied except; ▪ Factor no.6 (1 Item) | Satisfied except; ▪ Factor no.5 (1 Item) | Satisfied except; ▪ Factor no.5 (1 Item) | Satisfied |
| Factor loading of the variable | => 0.5 | Satisfied | Satisfied | Satisfied | Satisfied |
| Cross loading variable | => 0.5 on two factors or more | ▪ BEM2, BEM8 and BEM25. | ▪ BEM25 | ▪ DEM25 | Satisfied |
| Action taken for the next run "Removed item" | | DEM2 "Cross loading on Factor No.3 & Factor No.6" & "Loaded alone on Factor No.6" | BEM14 "Communality value < 0.5" | DEM25 Cross loading on Factor No.2 & Factor No.5" "Loaded alone on Factor No.5" | Final four factors solution (All requirements were satisfied) |

- Extraction method : Principal components analysis (PCA).
- Rotation method : Orthogonal Varimax rotation.
- MSA: Measure of sampling adequacy for each variable.
- KMO: Kaiser-Meyer-Olkin measure of sampling adequacy.
- No. of extracted factors : Factors with eigenvalue larger than 1.
- Cross loading variable: Variable that loaded at 0.50 or higher on two or more factors.

Table (4.26): Final results of factor analysis for energy management adoption barriers

| Item | Energy management adoption barriers " variables & factors" | Factor loading | Eigenvalue | % variance explained | Cornbach' α |
|---|---|---|---|---|---|
| ***Factor no.1: Economic\Financial*** | | | | | |
| BEM29 | Low profit margins gained from adopting energy management practices. | 0.81 | | | |
| BEM27 | Construction energy costs are not sufficiently important compared with other costs. | 0.79 | | | |
| BEM26 | High costs of energy management options (measures/technologies) | 0.79 | | | |
| BEM12 | Additional costs needed to improve the company energy efficiency | 0.79 | 5.48 | 18.24 | 0.90 |
| BEM28 | Lack of budget funding to adopt energy management practices and technologies. | 0.78 | | | |
| BEM31 | Uncertain local economic environment.. | 0.76 | | | |
| BEM30 | Lack of innovative energy technologies/equipment in local market. | 0.72 | | | |
| BEM6 | High competition between the local contracting companies working in the construction sector. | 0.63 | | | |
| ***Factor no.2: : Knowledge\Information*** | | | | | |
| BEM23 | Lack of technical skills\knowledge on construction energy management technologies. | 0.84 | | | |
| BEM19 | Lack of the client/donor awareness of the importance of energy management during onsite construction. | 0.84 | | | |
| BEM24 | Lack of training and education in energy management, sustainable design and construction. | 0.79 | | | |
| BEM20 | Resistance to change from traditional practices to more energy efficient practices. | 0.74 | 4.92 | 15.80 | 0.88 |
| BEM18 | Lack of the company staff awareness on the importance of energy management during onsite construction. | 0.73 | | | |
| BEM21 | Management believe that there is no/little scope for the company energy performance improvement . | 0.72 | | | |
| BEM8 | Difficulties to access technical information and expertise related to energy management in construction. | 0.65 | | | |

Table (4.26): Final results of factor analysis for energy management adoption barriers "Continued"

| Item | Energy management adoption barriers " variables & factors" | Factor loading | Eigenvalue | % variance explained | Cornbach' α |
|---|---|---|---|---|---|
| ***Factor no.3: Legal\Contractual*** | | | | | |
| BEM9 | The contract documents do not impose any special conditions/specifications for onsite energy management. | 0.89 | | | |
| BEM4 | Lack of energy management codes and regulation in construction. | 0.85 | | | |
| BEM1 | Lack of governmental legislations for environment protection and energy conservation in construction sector. | 0.85 | 3.74 | 14.98 | 0.91 |
| BEM15 | Poor enforcement of the governmental legislations related to energy issues in construction industry. | 0.82 | | | |
| BEM3 | Lack of government support/ incentives for energy management in construction industry. | 0.78 | | | |
| BEM5 | Lack of audit and quantitative evaluation tools for the energy performance of the construction companies . | 0.73 | | | |
| ***Factor no.4: : Organizational/Management*** | | | | | |
| BEM22 | Conflicts of interest within the project members (owner/consultant/contractor). | 0.80 | | | |
| BEM7 | Fragmentation of the construction process (Increased industry parties and divided processes). | 0.77 | | | |
| BEM10 | Company senior management doesn't provide support for energy saving activities | 0.74 | | | |
| BEM16 | The company lacks of ethical standards and corporate social responsibility. | 0.73 | 3.47 | 13.86 | 0.85 |
| BEM13 | The company lacks long-term vision and it is short-term oriented. | 0.72 | | | |
| BEM11 | Company management lack interest in onsite energy costs and consumption issues. | 0.66 | | | |
| BEM17 | Tight project duration makes the management concerned about the time required to adopt energy management practices. | 0.63 | | | |

*Kaiser-Meyer-Olkin measure of sampling adequacy = 0.73*
*Bartlett's test of sphericity: x2= 1209.36, df=378, p-value =0.00*
*Total variance explained (%) = 62.88 %*
*Total reliability Cornbach's α = 0.81*

***Third phase of factor analysis for energy management adoption barriers: Factors naming and interpretation.***

As such, the exploratory factor analysis on 28 variables that represent barriers for energy management adoption in local contracting companies identified four factors. These four factors were found to be significant enough to be used for further analysis. Once these factors determined, they should be named and interpreted to know what they are represent. Because PCA only groups variables together, possible names for each component can be proposed on the basis of the understanding of the content or relationship among these variables. The four factors extracted here were appraised to identify the underlying features that the loaded items have in common. This was done by looking for patterns of similarity between items that load on a factor. In addition, looking at what items do not load on a factor, to determine what that factor is not (Field, 2005). Thus, according to the understanding of the relationships and contents of the variables involved in each factor, possible names and interpretations can be proposed.

Accurately, several classifications have been proposed by many researchers for the barriers for energy management and other environmental issues. These classification mainly can help in naming the factors extracted and verifying the results obtained by factor analysis. UNEP (2006) identified four categories of the barriers to energy efficiency which were management, knowledge/information, financing and policy. Four barrier domains were categorized by Liu (2012) including structural, regulatory, contextual and cultural, of which the structural and regulatory barriers were most frequently mentioned. Another useful scheme has been developed by Weber (1997), which distinguished between institutional barriers, market barriers, organizational barriers; and behavioral barriers. According to the research conducted by Qi et al. (2010), the main barriers of green construction were classified into 4 fundamental aspects, i.e. economics, technology, awareness and management, where 15 potential barriers were identified. Sorrell et al. (2011) provided a relevant contribution with their efforts to formulate a comprehensive taxonomy of all barriers by identifying fifteen such barriers and dividing them into three groups; economic, behavioral and organizational
In the factor model, the total variance that was explained by the four factors accounted for 62.88% of the total cumulative variance. The factors extracted to represent the energy management barriers have been labeled as follows:

- **Factor no.1**: ***Economic and Financial***; comprised of 8 items and has 5.48 eigenvalue which accounts for 18.24% of the total variance .
- **Factor no.2: *Knowledge and Information***; comprised of 7 items and has 4.92 eigenvalue which accounts for 15.80% of the total variance
- **Factor no.3: *Legal and Contractual***; comprised of 6 items and has 3.74 eigenvalue which accounts for 14.98% of the total variance
- **Factor no.4: *Organizational and Management***; comprised of 7 items and has 3.47 eigenvalue which accounts for 13.86% of the total variance

Suggested labels for the extracted factors have been revised by three experts to obtain more representative labels. No suggestions have been obtained from experts in this direction.

Figure (4.8) illustrates the proposed designation for the components. The next section will interpret and discuss each of these components. This figure illustrates that contractors agreed that all these categories were the main barriers to implement energy management practices in local construction sector during project construction.

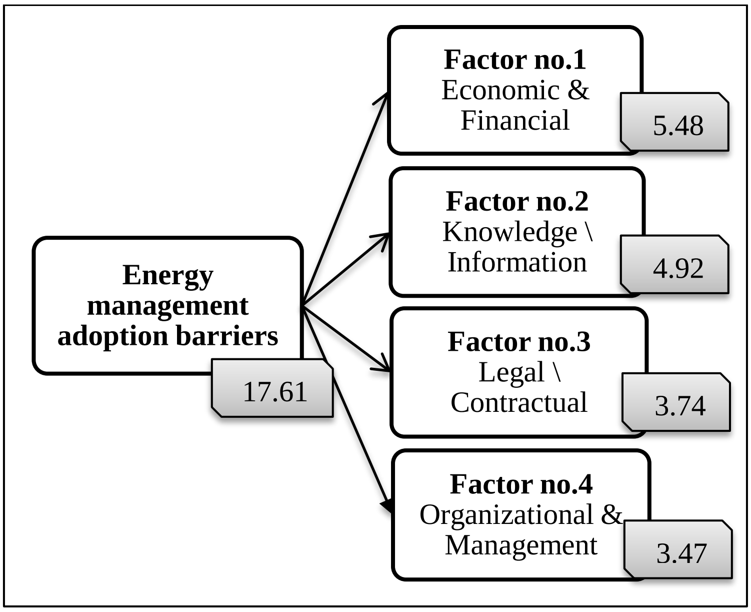


Figure (4.8): Final factors extracted from factor analysis for energy management adoption barriers.

❖ **Interpretation of the principal factors for the barriers to adopt energy management in local construction contracting firms.**

The results obtained from the previous processes have been interpreted here and wider discussion on each factor has been presented. In the following sections, general discussion about the four factors extracted from factor analysis has been prepared. In addition, the contents of each factor have been assessed and verified, as follows;

***a) Factor no.1 : Economic and Financial***

This factor accounts for 18.29% of the total variance and comprises 8 items. The majority of items enjoy relatively large factor loadings (>0.50). This first factor was labelled *"Economic and Financial"* because the contained items addressing issues related to financial or economic basid barriers for energy management adoption in local contracting companies during project construction. This factor explains the largest percent of variance from the other three factors, which mean that the factor *"Economic and Financial"* is the most important barriers group in impeding the application of energy management in local construction sector. Therefore, this result denoted that economic and financial aspects considered highly by local contractors when take any decision to energy management adoption during project construction. It is well recognized that cost effectiveness is one of the most important considerations for decisions of implementing any development in construction industry (De Groot et al., 2001; Ochieng et al., 2014). Research done by Zhang et al. (2011) argued that using green materials would cost from 3% to 4% more than conventional construction. Šaparauskas and Turskis (2006) argued that profit-driven culture in construction industry limited the effectiveness of the sustainable construction practices. Low profit can be caused by the higher costs associated with green materials and using green construction technologies (Hwang and Tan, 2010). WEC (2004) supported this result by considering the difficulty of obtaining the necessary financing as too often a major barrier to energy conservation projects. In addition, Apeaning and Thollander (2013) studied the barriers to use energy efficiency measures in Ghana's industrial area. Their results confirmed that economic barriers was the most important factors impeding the implementation of energy efficiency technologies. Meryman and Silman (2004) identified three primary barriers for using specifications in sustainable engineering. They argued that the economic factor was the most critical barrier. Economic approaches such as fiscal and tax policies can be used to give guidance and support for energy strategies and programming, and contribute to the application of new energy technologies and products, and development of new and renewable energies (Jiang, 2008).

The main concept of the exploratory factor analysis is to group many variables into smaller number of factors based on correlation between these variables and the factors so derived may be treated as new variables can account for the pattern of correlations between the involved variables (De Vaus, 2002;  Kothari.2004).Therefore, each one of the four factors extracted on the basis of the correlation between many variables from the variables included in analysis. So that, the first factor *"Economic and Financial"* generated as a result of the relationship between the variable comprises this factor. The correlation matrix of these variables has been produced and scanned to certify the results obtained from the factor analysis conducted on the 31 barriers for energy management. From Table (4.12) below, the correlation coefficient between each pair of the eight variables ranged between 0.42 and 0.72. according to De Vaus (2002) assumption, the strength of the relationship between each pair of these eight variables can considered relatively strong because all values of the correlation coefficients (r) were larger than 0.3. For example, The variable\item BEM6 correlated with each one of the other seven variables by a correlation coefficient larger than 0.3 to form the first factor with a correlation coefficients (r) equal to 0.43, 0.42, 0.47, 0.58, 0.42, 0.59 and 0.42 with the items *BEM12*, *BEM26*, *BEM27*, *BEM28*, *BEM29*, *BEM30* and *BEM31*, respectively. These results verified the grouping of these eight variables\items in one factor *"Economic and Financial"* as these variables emerged from the same concept related to economical or financial issues. In addition, the extracted factor  alone can play an important role identical to the roles of the eight barriers comprised this factor in impeding the adoption of energy management in local construction sector.

Table (4.27): Pearson correlations between the items "barriers" in *"Economic and Financial"* factor

| Item | BEM6 | BEM12 | BEM26 | BEM27 | BEM28 | BEM29 | BEM30 | BEM31 |
|---|---|---|---|---|---|---|---|---|
| BEM6 | 1.00 | | | | | | | |
| BEM12 | 0.43** | 1.00 | | | | | | |
| BEM26 | 0.42** | 0.59** | 1.00 | | | | | |
| BEM27 | 0.47** | 0.55** | 0.72** | 1.00 | | | | |
| BEM28 | 0.58** | 0.52** | 0.46** | 0.60** | 1.00 | | | |
| BEM29 | 0.42** | 0.59** | 0.62** | 0.54** | 0.56** | 1.00 | | |
| BEM30 | 0.59** | 0.49** | 0.47** | 0.52** | 0.59** | 0.57** | 1.00 | |
| BEM31 | 0.42** | 0.50** | 0.44** | 0.51** | 0.64** | 0.58** | 0.52** | 1.00 |

***. Correlation is significant at the 0.01 level (2-tailed).*

### b) *Factor no.2 : Knowledge and Information*

A further primary group of barriers for energy management adoption identified by the respondents was *"knowledge and information".* This is attributable primarily to their lack of energy management know-how and information. Therefore, this factor was named *"Knowledge and Information"*, which accounts for 15.80% of the total variance and comprises 7 items\barriers. Kostka et al. (2013) provided a description for the informational barriers which refer to the problems and costs related in process of gathering, assessing and applying information about energy saving potentials and relevant technologies. The second barrier group of the study carried out by UNEP (2006) was about knowledge and information and covered the limited information and (technical) knowledge at company level, also a limited access to or availability of knowledge and information. However, De Groot et al. (2001) explained that, lack of information is a principal source of industrial market failures to implement energy saving technologies. In general, this type of barriers can deeply influence the processes of translating energy and carbon management awareness into behavior (Liu, 2012). Limited knowledge and information was also identified by Apeaning (2012) to impede the progress of energy efficiency. Generally, a minimum technical knowledge of energy, production processes and equipment is required to be able to identify, investigate and implement options to improve resource and energy efficiency (UNEP, 2006). If there is a lack of information and know-how the decisions are not as rational as they could be. The information and knowledge barriers are considered as the single largest barrier (Jarnehammar et al., 2008). This result agrees with Eisenberg et al., (2002) study which proved that insufficient knowledge or technical expertise and unfamiliarity with the products, materials, system, or design are the main challenges for green construction.

In addition, Shari and Soebarto (2012) observed that, lack of technical understanding among project team members, explaining the absence of sustainability consideration on their agenda. Abidin (2009) identified that, the lack of the technical knowledge on green technologies and materials among construction practitioners in Oman considered as a significant challenge to the industry for the implementation of green strategies and Specifications. . Lack of skills and knowledge on energy management was explained by Muhaisen and Ahlbäck (2012), who indicated that there are no vocational training centers offer any courses on sustainable construction in Gaza Strip, especially, courses related to energy efficiency or renewable energies, in the same time the teaching in these fields on higher levels is also very limited. This result indicated that most of the contracting firms in Gaza Strip lacked skilled personnel to evaluate the performance of an energy efficiency technology and also operate the technology; this limitation inhibited the ability of local contracting companies to take up energy management and saving technologies. Lack of experienced persons occurred because construction energy management still relatively new in Gaza Strip. In addition, local construction sector is dominated by local contractors who are not interested in technology changes involving risks and extra costs, and most of all they do not have the experience, knowledge and capital to implement such policies and strategies. On other hand, informational factors are not limited to lack of knowledge about a technology or process improvement, but may include lack of awareness about the financial benefits of some energy efficiency improvements and other uncertainties that may prevent uptake (ClimateWorks-Australia, 2013).

Plessis (2002) pointed out that the client has an important role to play in the sustainability of construction by including sustainability criteria into the procurement policies and procedures. It is the responsibility of the client to specify the use of technologies that reduce the consumption of resources over the lifetime of a building and to consider life cycle costs in addition to the capital costs (Dewick and M. Miozzo, 2002). Ochieng et al. (2014) attributed the lack of client awareness to the lack of training on sustainability issues by several institutions and professional bodies, lack of clear structure and guidance and the nature of relevant codes of practice in terms of being advisory rather than mandatory. In addition, clients are not willing to pay premium prices for sustainable practices, it falls back on the contractor to make this sacrifice to their profit in order to achieve sustainable construction (Khalfan et al. 2015). In consistent of this result, Shi et al. (2013) note that the contractors were more inclined to agreed that most efforts should be made to improve clients' awareness of green construction and it is more likely to adopt green construction if clients are more aware of green technology and willing to implement these technologies in their projects. In local conditions, lack of the client/donor awareness of the importance of energy management during onsite construction results in perceiving energy efficiency improvement specifications and conditions as secondary when preparing the contract documents and when selecting the contractor to complete the project. So that, progress on sustainability and energy management in local construction sector depends on people in the industry being aware of the importance of this issue, and then being able and willing to act on it.

In order to validate the factor analysis results, statistical analysis was undertaken to show the relationship between the items included in the second factor. An evaluation of the linear relationship between the items included in the second factor was measured using Pearson's correlation. Table (4.28) below, presents the correlation matrix between the items forming the second factor *"Knowledge and Information".* From this table, it is clear that the four items inter-correlated with a correlation coefficient ranged from 0.38 to 0.7 . This result indicated that these items significantly correlated together by relatively strong degree (r > 0.3), besides that, the correlations between them reflects the mutual effects between them, which mean that increase in one item will cause increase in other items. The correlation analysis implies that these seven items and its grouping factor determine the company direction to adopt energy management.

Table (4.28): Pearson correlations between the items "barriers" in "Knowledge and Information" factor

| Item | BEM8 | BEM18 | BEM19 | BEM20 | BEM21 | BEM23 | BEM24 |
|---|---|---|---|---|---|---|---|
| BEM8 | 1.00 | | | | | | |
| BEM18 | 0.43** | 1.00 | | | | | |
| BEM19 | 0.47** | 0.53** | 1.00 | | | | |
| BEM20 | 0.42** | 0.45** | 0.64** | 1.00 | | | |
| BEM21 | 0.45** | 0.64** | 0.51** | 0.38** | 1.00 | | |
| BEM23 | 0.49** | 0.46** | 0.70** | 0.50** | 0.53** | 1.00 | |
| BEM24 | 0.40** | 0.50** | 0.68** | 0.54** | 0.42** | 0.70** | 1.00 |

***. Correlation is significant at the 0.01 level (2-tailed).*

### c) ***Factor no.3 : Legal and Contractual***

This cluster explained 14.98% of the total variance and was represented by six variables (barriers). These six barriers have a an acceptable factor loadings larger than 0.5. This factor involves a number of legal and contractual barriers which explaining why energy management measures with environmental and economic benefits are not implemented during project construction in local contracting companies. Accurately, this type of barriers caused by the government and the construction regulatory institutions because they didn't' impose policies, legislation and planning for sustainable and energy efficient construction. Another reasons for this challenge is the lack of energy management codes and lack of governmental support. All mentioned reasons could make legal and contractual aspects as one of the major barriers to implementing energy management. Guiding and regulating energy development and utilization by legal measures is the common practice in many countries (Jiang, 2008). However, governments focused mainly on improving domestic production and increasing the number of industrial plants and did not consider the energy efficiency aspect (Ates and Durakbasa, 2012). In addition, policy makers frequently overlook the opportunities presented by industrial energy efficiency to have a significant impact on climate change mitigation, security of energy supply, and sustainability (UNIDO, 2007). Therefore, if the government or construction professionals enforce standards for the environment and energy management in the construction industry then its implementation is likely to progress quickly.

However, currently there are neither proper standards in place nor any efficient monitoring of working conditions in the construction sector in Gaza Strip (Muhaisen and Ahlbäck, 2012). Ochieng et al. (2014) explained the importance of the policies, regulations, incentives and commitment by leadership to move towards the realization of sustainable developments. In the line with this result, the respondents of the study conducted by Majdalani et al. (2006) in Lebanon agreed that the current environmental regulations and policies in construction sector are minimal. In addition, they argued that all construction stakeholders should participate and try to balance the sustainability long-term benefits with the short-term ones. Recently, lack of government pressure was ranked by Abd Elkhalek et al. (2015) as significant obstacle for the implementation of environemental management system in the Egyptian construction industry.

To attain more success, various professionals and all other stakeholders of building sector will have to be involved in the legislative process for meaningful and functional legislative measures (Akinbami and Lawal, 2009). So that, environmental friendly practices are one of the most important requirements from clients to contractors and the failure to meet these requirements may lead to the removal of the concerned contractors from tender lists (Qi et al., 2010). Therefore, if there is no perceived energy management conditions in the contract, contractors are not motivated to apply energy management technologies. Naturally, increased demand by clients and owners for sustainable requirements in the contract documents can push the contractors to adopt more sustainable practices (Djokoto et al., 2014). For that, the study conducted by Shi et al. (2013) indicated the existence of a high level of agreement among clients, contractors and construction supervision engineers that environmental requirements should be taken into consideration in specifications. However, today's contracting and tendering process in local construction sector have lots of drawbacks, focusing on low cost and less time and ignorance of performance, that affect the energy management movement negatively. In fact, developing specifications in the initial stages of construction projects to address the sustainable goals will have impact in eliminating the disputes in later stages (Rao and Pavan, 2013).

An analysis using Pearson's correlation coefficient in Table (4.29) below, indicated that there is a significant linear relationship between the six barriers formed "Legal and Contractual" factor. Clearly, these items measures the efficiency of the legal and contractual barriers in prohibiting the adoption of energy management in local construction sector. So that, the significant associations between them are reasonable. Strong correlations within the items\variables included in this factor indicated the high mutual effects between these variables in impeding energy management adoption in local contracting companies. The correlation coefficients between these six variables ranged from  and their values were larger than 0.3. So that, these correlation coefficients strengthened the findings presented in factor analysis which grouped all of these six barriers under one heading.

Table (4.29): Pearson correlations between the items "barriers" in "Legal and Contractual" factor

| Item | BEM1 | BEM3 | BEM4 | BEM5 | BEM9 | BEM15 | BEM1 |
|---|---|---|---|---|---|---|---|
| BEM1 | 1.00 | | | | | | |
| BEM3 | 0.62** | 1.00 | | | | | |
| BEM4 | 0.70** | 0.63** | 1.00 | | | | |
| BEM5 | 0.55** | 0.59** | 0.51** | 1.00 | | | |
| BEM9 | 0.78** | 0.65** | 0.74** | 0.54** | 1.00 | | |
| BEM15 | 0.58** | 0.51** | 0.65** | 0.53** | 0.71** | 1.00 | |
| BEM1 | 0.40** | 0.50** | 0.68** | 0.54** | 0.42** | 0.70** | 1.00 |

***. Correlation is significant at the 0.01 level (2-tailed).*

### d) ***Factor no.4: Organizational and Management***

The fourth factor was labelled *"Organizational and Management"* comprised seven items and explains about 13.86% of the total variance and including the items addressing aspects related to the managerial or organizational aspects that prohibiting energy management adoption. It is shown that these seven items appear with acceptable large loadings (> 0.50) on this factor. With the lowest value of variance explained, the theme of *"Organizational and Management"* barriers can be considered to be the least significant of the themes of barriers and challenges. In general, the *"Organizational and Management"* barrier pertains to features of a firm's structures and procedures that influence both the day-to-day operation and long term strategy direction. These barriers indicated that local construction companies haven't tried to change their management systems in order to implement sustainability and energy management principles. Today, construction stakeholders worldwide are transforming their organizational structures to implement sustainable building practices (Lee et al., 2014). De Groot et al. (2001) recognized that organizational constraints can be thought of as difficulties in incorporating the technology in the existing production process due to, for example, a lack of capable employees, a lack of internal knowledge or a lack of physical space.

Major characteristic of the construction industry is the involvement of a large number of individuals ranging from clients to the builder thus an effective steering or strategy will be required to implement sustainable construction (Djokoto et al., 2014). Moreover, the construction process is usually fragmented and involves several parties with different objectives. Thus, often none of them normally assumes direct responsibility for protecting the environment (Šaparauskas and Turskis, 2006). Therefore, involvement of all stakeholders is a crucial aspect to achieve sustainable construction since the industry itself is highly fragmented (Majdalani et al., 2006). In addition, due to the fragmented structure and project-based nature of the construction industry, the effective adoption of innovation, and particularly of environmental innovation, requires the participation and collaboration of all the parties in the industry (Dewick and Miozzo, 2002). Suliman and Omran (2009) argued that all actors construction and building sector should be working together as a chorus to ease the transition towards environmental sustainability. So that, it is not surprising to see that the barriers *"Conflicts of interest within the project members (owner/consultant/contractor)" BEM22 and "Fragmentation of the construction process (Increased industry parties and divided processes)" BEM7,* as significant items in the fourth factor of the barriers for energy management adoption.

In Gaza Strip, contractor is not the only stakeholder of project construction. Thus, cooperation with other stakeholders including client, consultant and donor etc., is required, and the each one of them often plays an important role. The functional gaps and discontinuities in the building delivery process between all stakeholders established the difficulties in the improvement of the energy efficiency of the built environment (UN Global Compact and Accenture, 2012). Although there is some awareness about the concept of energy management, Palestinian construction companies have little knowledge and experience on energy management standards and techniques. This problem brings the question that what should be done to create and develop energy management system of construction companies. Local construction sector is very conservative and not in favor of change, so that its organization has not changed from a long time.

The correlation matrix for the seven items involved in the *"Organizational and Management"* factor presented in Table (4.30). It is clear that the seven variables correlated together with a correlation coefficient larger than 0.3 and ranged 0.32 to 0.57. These relatively strong associations are logic as these barriers fundamentally are related to managerial or organizational issues of the barriers for energy management adoption. So that, the results obtained by factor analysis can be confirmed as *"Organizational and Management"* produced as a common factor accounts for the relationship between the involved seven items. Therefore, this relationship is typically measured through factor analysis method.

Table (4.30): Pearson correlations between the items “barriers” in “Organizational and Management” factor

| Item | BEM7 | BEM10 | BEM11 | BEM13 | BEM16 | BEM17 | BEM22 | BEM7 |
|---|---|---|---|---|---|---|---|---|
| BEM7 | 1.00 | | | | | | | |
| BEM10 | 0.46** | 1.00 | | | | | | |
| BEM11 | 0.52** | 0.43** | 1.00 | | | | | |
| BEM13 | 0.52** | 0.42** | 0.42** | 1.00 | | | | |
| BEM16 | 0.49** | 0.48** | 0.35** | 0.41** | 1.00 | | | |
| BEM17 | 0.32** | 0.43** | 0.40** | 0.44** | 0.36** | 1.00 | | |
| BEM22 | 0.55** | 0.53** | 0.32** | 0.46** | 0.57** | 0.54** | 1.00 | |

*** Correlation is significant at the 0.01 level (2-tailed).*

## 4.7 Best activities to save energy of construction projects in Gaza Strip.

On the basis of the assumption that industrial firms consider energy management as a means, not an end in itself, the researcher decided to ask for activities leading to energy savings and which can be considered as main parts of energy management system. Proposing a confident methods for local construction managers to save energy in construction projects is one of the most important results of this study. Therefore, this part intended to identify and propose a list of most effective activities (methods) to save energy use and costs in local construction projects. This section presents the survey results regarding the activities that could be useful in assisting local contracting companies to improve their energy management and efficiency. Vesma (2012) identified price and quantity as the basic two facets related to energy costs reduction. Therefore, the proposed activities in this research were concerned with each of these facets. To deliver energy saving in construction project, fundamental changes are required in the way the construction industry operates. As already mentioned in the literature, there are many developed methods and techniques available to save energy in construction projects. All of them can contribute significantly, if not more, in reducing the amount and cost of energy required and the environmental impacts caused as a result of energy use such as CO2. By adopting these activities, energy saving in cost and amount can be achieved without compromising on the safety, quality, durability and aesthetic aspect of the project under construction. In general, providing a comprehensive list of energy management activities is important for local contractors, as it will help them to plan, review, benchmark and allocate energy resources better, to put it simply, it can be understood as “what” are the best to be done to achieve energy saving goal. Energy management activities identified in this study are meant to provide guidance and inspire local construction companies to take action to reduce the amount of energy used in construction projects and hence, provide efficient implementation of energy management system.

A literature review and experts discussions were used to develop the preliminary set of the activities to integrate energy management adoption in local contracting companies. The usefulness degree of the proposed 33 energy saving and management activities (*SEM1* to *SEM33*) was investigated through the sixth section of this study questionnaire which was sent to various contracting companies to gather their perception about these activities with the construction industry in Gaza Strip. By focusing on specific energy saving activities, it comes easy to ensure that the firm is actively attempting to achieve energy management. This study provides a useful reference to both policy makers and industry practitioners to efficient energy use in construction. The following sections provide a detailed description of the descriptive and inferential statistics performed on the proposed energy saving activities.

### 4.7.1 Relative Importance Indexes (RIIs) and Ranking of the activities for energy management in construction

Table (4.31) summarizes the analysis results related to the part around what can be done to improve energy saving during project construction projects in Gaza Strip. The energy saving activities were ranked in ascending order of their effectiveness to save energy during project construction based on the relative importance index (RII) of these activities. These rankings made it possible to cross-compare the relative importance of the activities as perceived by the respondents. In addition, assessing the general and overall rankings of these activities can help to give an overall picture of the best activities to save energy during project construction in Gaza Strip. Other statistics regarding to the proposed activities including, the mean score (MS), standard deviation (SD), and its one sample t-test results (t-values and p-values) are also shown in Table (4.31). Additionally, graphical presentation of RIIs values for the recommended activities to save energy in construction were provided in Figure (4.9).

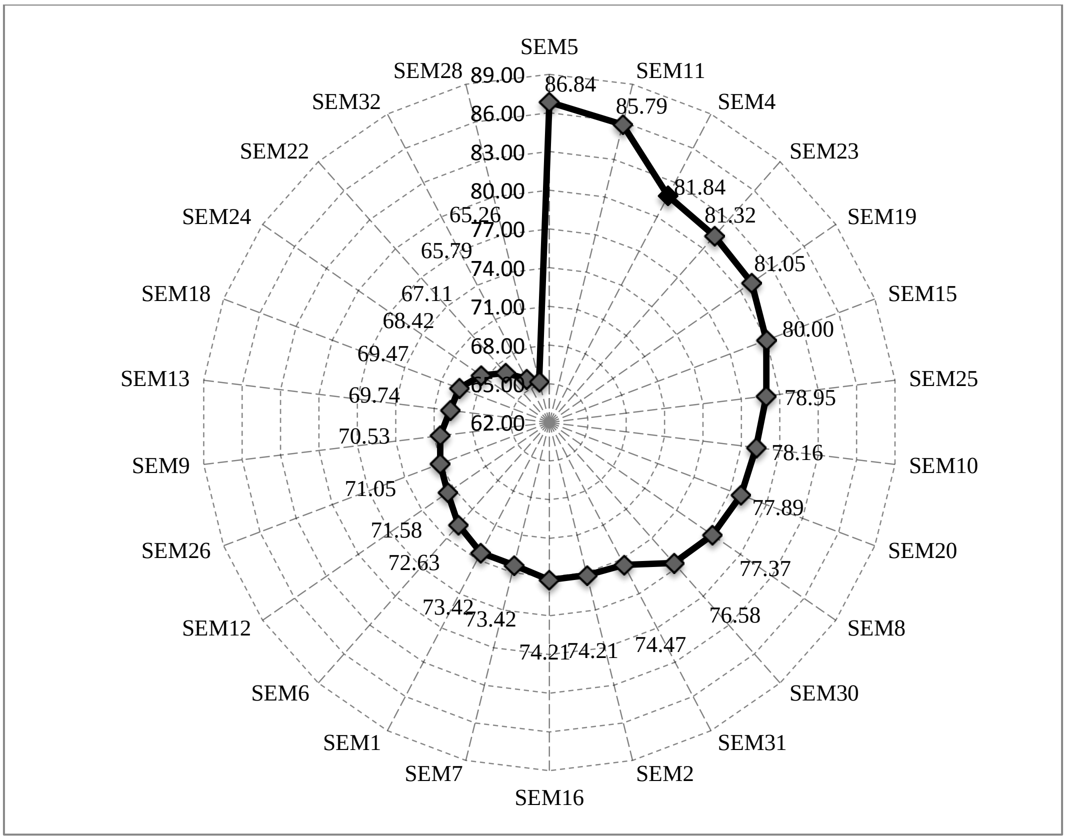


Figure (4.9): RII of best activities to save energy "*SEM1* to *SEM33*"

Table (4.31): Analysis results of the best activities to save energy in construction

| No. | Energy saving activity | MS | RII | SD | t-value | P-value (2-tailed) | Rank |
|---|---|---|---|---|---|---|---|
| SEM5 | Adoption of more energy efficient construction methods as opposed to traditional construction methods during construction phase. | 4.41 | 88.16 | 0.72 | 17.16 | 0.00 | 1 |
| SEM11 | Conducting energy audits on the construction site to identify energy use and energy saving opportunities. | 4.30 | 86.05 | 0.75 | 15.17 | 0.00 | 2 |
| SEM4 | Motivate the company employees to apply more onsite energy saving practices. | 4.22 | 84.47 | 0.81 | 13.17 | 0.00 | 3 |
| SEM23 | Reducing the unnecessary use of energy consuming equipment and machines used during onsite construction. | 4.09 | 81.84 | 0.90 | 10.61 | 0.00 | 4 |
| SEM19 | Use of a monitoring system for energy use during onsite works. | 4.01 | 80.26 | 0.84 | 10.51 | 0.00 | 5 |
| SEM15 | Collect information on available energy saving systems, technologies and policies in local construction sector. | 4.00 | 80.00 | 0.80 | 10.90 | 0.00 | 6 |
| SEM25 | Replacement of onsite mechanical equipment with the use of manual labor where applicable. | 3.96 | 79.21 | 0.81 | 10.37 | 0.00 | 7 |
| SEM10 | Development of adequate energy database for the company projects. | 3.92 | 78.42 | 0.86 | 9.33 | 0.00 | 8 |
| SEM20 | Conducting periodic meetings and training programs for the contractors staff in energy conservation systems/technologies. | 3.91 | 78.16 | 0.90 | 8.82 | 0.00 | 9 |
| SEM8 | Setting a quantitative targets for onsite energy use and saving in each activity of the project. | 3.88 | 77.63 | 0.94 | 8.20 | 0.00 | 10 |
| SEM30 | Using available energy saving technologies and solutions during onsite construction. | 3.88 | 77.63 | 0.83 | 9.24 | 0.00 | 11 |
| SEM31 | Utilization of renewable energies and green technologies for onsite production, transport and performance. | 3.82 | 76.32 | 0.80 | 8.94 | 0.00 | 12 |
| SEM2 | Adopting of the governmental fiscal measures related to onsite construction energy issues. | 3.80 | 76.05 | 0.95 | 7.35 | 0.00 | 13 |
| SEM16 | Establishing good onsite communications between project staff about energy matters during construction phase. | 3.79 | 75.79 | 0.84 | 8.22 | 0.00 | 14 |
| SEM7 | Selecting subcontractors who are experienced in energy issues and management in construction . | 3.74 | 74.74 | 0.82 | 7.81 | 0.00 | 15 |

Table (4.31): Analysis results of the best activities to save energy in construction " Continued"

| No. | Energy saving activity | MS | RII | SD | t-value | P-value (2-tailed) | Rank |
|---|---|---|---|---|---|---|---|
| SEM1 | Applying the governmental regulations requirements related to construction energy use. | 3.71 | 74.21 | 0.91 | 6.83 | 0.00 | 16 |
| SEM6 | Participating in environmental friendly projects as possible. | 3.68 | 73.68 | 0.87 | 6.88 | 0.00 | 17 |
| SEM12 | Systematic review and analysis for the energy consumption of onsite activities and equipment. | 3.67 | 73.42 | 0.91 | 6.39 | 0.00 | 18 |
| SEM26 | Practicing of onsite construction methods leading to lower material use . | 3.63 | 72.63 | 0.81 | 6.76 | 0.00 | 19 |
| SEM9 | Developing scientific, reasonable energy action plan for the project to make full use of onsite energy and resources. | 3.55 | 71.05 | 0.81 | 5.97 | 0.00 | 20 |
| SEM13 | Optimization of the transportation of raw materials and equipment to and within the site. | 3.54 | 70.79 | 0.79 | 5.95 | 0.00 | 21 |
| SEM18 | Detailed reporting of the company onsite energy activities. | 3.53 | 70.53 | 0.70 | 6.54 | 0.00 | 22 |
| SEM24 | Replacement of high energy consuming equipment with lower energy consuming equipment. | 3.49 | 69.74 | 0.79 | 5.36 | 0.00 | 23 |
| SEM22 | Frequent examination of the energy efficiency of all equipment used on construction site. | 3.45 | 68.95 | 0.74 | 5.29 | 0.00 | 24 |
| SEM32 | Software development for onsite energy monitoring and evaluation. | 3.41 | 68.16 | 0.82 | 4.34 | 0.00 | 25 |
| SEM28 | Increasing the use of recycled building materials. | 3.33 | 66.58 | 0.79 | 3.63 | 0.00 | 26 |
| SEM33 | Using onsite energy manual (detailed work instructions) to save energy during onsite construction. | 3.30 | 66.05 | 0.67 | 3.92 | 0.00 | 27 |
| SEM29 | Reducing excessive material and wastage during onsite construction. | 3.29 | 65.79 | 0.73 | 3.47 | 0.00 | 28 |
| SEM21 | Identification and revision of the performance standards for the equipment used onsite . | 3.25 | 65.00 | 0.66 | 3.32 | 0.00 | 29 |
| SEM14 | Closer onsite supervision and quality control on energy issues. | 3.24 | 64.74 | 0.65 | 3.17 | 0.00 | 30 |
| SEM17 | Employing a specialized team or person responsible for all energy issues during onsite works. | 3.18 | 63.68 | 0.60 | 2.66 | 0.01 | 31 |

Table (4.31): Analysis results of the best activities to save energy in construction " Continued"

| No. | Energy saving activity | MS | RII | SD | t-value | P-value (2-tailed) | Rank |
|---|---|---|---|---|---|---|---|
| SEM27 | Selecting where possible only local sources of materials supply. | 3.12 | 62.37 | 0.52 | 2.10 | 0.04 | 32 |
| SEM3 | Adopting of the available energy code requirements for construction industry. | 3.08 | 61.58 | 0.58 | 1.18 | 0.24 | 33 |
| | Overall energy saving activities | 3.67 | 73.40 | 0.31 | 19.15 | 0.00 | --- |

- *MS: Mean Score* *RII: Relative Importance Index* *SD: Standard Deviation*
- *Critical t-value (two-tailed): at degree of freedom (df) = [N-1] = [76-1] = 75 and significance level 0.05 equals "1.99"*
- *The hypothesized population mean is the critical rating at 3.*

Field (2009) argued that there is little variability in the data and consistency in agreement among the respondents when the standard deviations are all less than 1.0 for 5-points Likert scale. So that, according to the results presented in Table (4.31), the standard deviation of all items (activities) indicated that the responses about these items concentrated around the mean because all items standard deviations were less than 1. Accordingly, it is clear that there was some agreement between the study respondents about the understanding of these activities. Furth more, the following discussion on the one sample t-test below can declare the reasons about this agreement.

One sample t-test was carried out to validate the perception of the respondents to the proposed activities to save energy in construction. This test was performed with a confidence level of 95%, at a specified value (hypothesized value) of 3 which is the average of the 5 point Likert scale. The majority of the p-values shown in Table (4.31), are less than 0.05 and major t-values are positive and larger than the critical value (1.99), which indicated that, the mean of population from which the sample is taken with (MS=3.67, SD=0.31) was significantly different from the specified value (hypothesized value= 3). In addition, the mean tests for all variables at 95% confidence level were higher than the hypothesized mean of point 3. According to these results, it can be emphasized that, the respondents agreed about the effectiveness of these activities in saving energy during project construction. Actually, these results suggest that energy saving can be achieved when any of these activities applied in local construction sector.

However, the activity *"Adopting of the available energy code requirements for construction industry" SEM3,* can be considered insignificant and the respondents haven't agreed that its existence is useful in saving energy in construction. This conclusion stemmed from the p-value=0.24, which is higher than the significance level of 0.05. In addition t-value of this item validates this conclusion because it was 1.18 and lower than the critical t-value of 1.99. Although the mean of this activity (MS=3.08) is slightly larger than the hypothesized value (3), its (p-value=0.24 > 0.05) and (t-value < 1.99) revealed that this activity is insignificant as the high mean is not the real value of the population and was obtained here by chance only. This perception delivered due to the absence of the energy code locally. In addition, construction industry participants in Gaza Strip generally haven't committed to the available construction codes for other aspects related to construction projects because local government or construction associations haven't enforced these codes requirements and considering it as a marginal issue. So that, even it exists, energy code can't improve energy efficiency of the local contractors. Sheffer and Levitt (2010) supported this conclusion as they observed that in some cases, codes can even decrease rate of innovation diffusion.

The average mean for all key activities is 3.67 and above the hypothesized average of 3 and the standard deviation is 0.31, lower than 1 with (p-value = 0.00 < 0.05) and (t-value = 19.15 >1.99). These results suggested that the practitioners are satisfied with the proposed key activities. The companies that mainly participated in the study considered the proposed energy saving activities useful to save energy in local construction sector . This result verified by the overall RII value which is higher than 60% (higher than average score "60% = (3/5)*100")

The findings on this part shows that most effective three activities in saving energy during project construction are; *"Adoption of more energy efficient construction methods as opposed to traditional construction methods during construction phase" SEM5*, with the highest RII= 88.16%, *"Conducting energy audits on the construction site to identify energy use and energy saving opportunities" SEM11*, with the second RII= 86.05% and *"Motivate the company employees to apply more onsite energy saving practices" SEM4,* with third RII=84.47.In addition, the activity *"Adopting of the available energy code requirements for construction industry" SEM3,* was ranked in the last position with RII=61.58%. It worth noting that, the activities with low RII don't mean that they were not important for saving energy, but rather they wanted to highlight the relative importance of the activities from their vantage point.

Generally, construction industry has been identified as one of the most unsustainable industrial sectors and there is increasing awareness of the need for improvement through initiatives such as the construction best practice program, and movement for innovation (Robinson et al., 2006). Additionally, increased energy use during construction process can be attributed to the traditional methods implemented by the contracting organizations to deliver projects. Ates and Durakbasa (2012) argued that many organizations considered energy management as a matter of technical settings, although the management and organizational side are also essential aspects. Therefore, Plessis (2002) claimed that construction industry environment impact can be mitigated through changes in the practices of the construction industry. In the line of aforementioned discussion, the activity *"Adoption of more energy efficient construction methods as opposed to traditional construction methods during construction phase" SEM5*, with (MS=4.41, RII=88.16%, SD=0.72 and p-value=0.00) was ranked in the first position of the proposed energy saving activities. This results implied that changing construction methods may seem impressive and attractive and it is the favorite solution for energy conservation. Local contractors believe that there is a strong relation between the construction methods and energy saving, if more modern construction methods used the more energy saving will be achieved; and that could be attained by the efficient use of resources and assuring the best quality that could be realized. To some extent, this can be attributed to the local contractors concerns on construction methods, as construction methods have more influence on construction companies. In addition, contractors are influential towards adopting energy efficient methods due to their main responsibility and impact of environmental management during the pre-construction and construction stages (Baloi, 2003). Indeed, contractors are knowledgeable of construction process and characteristics of various building materials and plants, their roles in contributing to better project sustainability are significant as they can provide information and suggestions about the environmental effects of construction activities and various materials and plant (Šaparauskas and Turskis, 2006). Besides, since the direct and indirect cost of employees and resources is more than the cost of energy or construction, even small change in productivity, resources use and construction method convert into enormous energy benefits.

In the same line, Akadiri et al. (2012) pointed out that developing energy efficient technological processes for construction is one of the best methods to conserve construction energy use. Fisher and Bristow (2009) asserted that sustainable building practices can result in reduced energy consumption. About 75% of the respondents in a study conducted by Khalfan et al. (2015) in Australia believed that sustainable construction methods provides a good return as compared to conventional buildings methods. The significance of this finding is in accordance with the conclusion presented by Muhaisen and Ahlbäck (2012), which revealed that applying different sustainable construction methods, materials, technologies and applications in Gaza is often feasible and can contribute to considerable improvements in materials, energy and water efficiency in buildings. However, UNIDO (2007) stated that, that installation of a more energy-efficient process will result in substantial energy savings over the life of the process. UNEP (2006) supported this finding by realizing that, company management in developing countries often consider new technologies as the only way to significantly improve resource efficiency. On the same line, Sustainability Victoria (2007) asserted that implementing effective energy management program requires changing company processes. Trianni et al. (2013) argued that the transition to a more sustainable production will require substantially different and innovative technologies and practices than those in use today. In the line with this result, Plessis (2002) argued that the first step towards sustainable construction is to improve the quality of construction products and the efficiency and safety of the construction process.

On the other hand, Enshassi (2000) concluded that, environmental effects from the construction industry can result from inappropriate construction site practices. In fact, defects and inefficient processes are expensive forms of wasting environmental resources and pose a danger to both construction workers and the end-users of the product (Plessis, 2002). UNIDO (2007) argued that energy losses are due to system inefficiencies that can be avoided through the application of commercially available technology combined with good engineering practices. The study conducted by Hong et al. (2015) concluded that, energy increment during construction process in different areas in China resulted from extensive construction activities and inefficient construction process. However, to satisfy this objective, it is clear that the various activities of the construction sector have to be regarded and analyzed when considering sustainable development (Suliman and Omran, 2009). In which, the company need to examine all construction processes to determine how much energy can be used and saved by changing processes or working procedures (Kahlenborn et al., 2010). In fact, innovative industrial technologies aim not only to reduce energy use, but also to improve productivity, reduce capital costs, reduce operation costs, improve reliability as well as reduce emissions and improve working conditions (Worrell and Price, 2001a).

Despite its influence, the limitation of the scope and applicability of new products and new technologies may force industry practitioners to move back to traditional construction methods (Shi et al., 2013). However, projects relating to process changes almost always involve high costs, generally complex and may require long lead times before they can be implemented (Bureau of Energy Efficiency, 2010). Powmya and Abidin (2014) supported this conclusion by a market survey carried out in Oman and they concluded that the transition from traditional to sustainable approach in the construction industry is a time consuming process as it requires changes in the perspectives of all stakeholders.

In summary, as large energy amounts used in construction process, more attention has to be paid to the energy use for the construction activities especially which consumes high amount of energy. So that, to speed up the development of new energy efficient construction methods local construction industry should learn the experience of the advanced methods of energy conservation and new energy development and utilization from developed countries. Energy efficient construction methods can be emerged to increase construction energy utilization efficiency, to optimize energy structure, to exploit and utilize new energy actively by technology innovation. The relative importance of the construction phase may also be expected to increase in the future since the energy use in this phase can be reduced substantially by means of well proven methods and technologies.

A key part of controlling energy use and cost is understanding where and when energy is consumed within a facility. A breakdown of energy use and cost for equipment and processes that are key contributors is often the most important step towards understanding current energy performance and targeting the energy conservation measures that will yield the greatest savings (Gorp, 2004). There for, among the most concrete activities to be taken by companies surveyed in this study to save energy was *"Conducting energy audits on the construction site to identify energy use and energy saving opportunities" SEM11*, which was located in the second position with (MS=4.30, RII=86.05%, SD=0.75 and p-value=0.00).

This finding illuminated that local construction contractors have realized the importance of energy audits in estimating typical energy costs for construction activities and equipment usage and to assess the level of progress of ongoing programs. The importance of this activity emerged from its cost effectiveness when implemented, so it should be possible to persuade contractors to implement it without additional financial cost. In addition, performing energy audits can raise the awareness within such companies for improving their energy efficiency (Trianni et al., 2013). More clearly, having performed an energy audit shed light on existing difficulties within an enterprise in implementing actions to improve energy and improved enterprises towards a greater awareness of what is effectively needed in order to shift towards more efficient production (Thollander et al., 2013). In addition, energy audit will help to understand more about the ways energy and fuel are used in any industry, and help in identifying the areas where waste can occur and where scope for improvement exists (Kannan and Boie, 2003). Turner and Doty (2009) reported that energy audit is one of the first tasks to be performed in the accomplishment of an effective energy cost control program. Hwang and Tan (2012) recommended that to support the building environment management and to ensure that sustainable practices are implemented during project construction, on site checking and auditing should be conducted on fixed intervals.

Energy audit is an essential first step in identifying opportunities that can contribute to an organization's energy efficiency targets (UNIDO, 2007). UNCHS (1991) declared that conducting energy audits on typical construction sites to identify energy use and energy saving opportunities is the best strategy for improving energy use efficiency in construction. Abdelaziz et al. (2011) and Jain and Kaur (2013) reported that, energy audit is the key for decision-making in the area of energy management. It helps any organization to analyze its energy use and discover areas where energy use can be reduced and waste can occur, plan and practice feasible energy conservation methods that will enhance their energy efficiency. By conducting energy audits of different industries in Palestine, Yaseen (2008) identified the energy efficiency opportunities available in the industrial sector. Ibrik and Mahmoud (2005) expected savings to be achieved upon the implementation of the audit recommendations range from about 10% to 15% of the total energy consumption.

It is clear that once the decision to conduct more energy efficient methods was taken, energy audit is the next step. Most respondents reported having systems in place to collect and manage energy data and staff to manage energy use as critical to achieving any significant energy efficiency. Energy audit should be conducted to review existing practices, investigate energy usage and provide insight into particular inefficient activities (Wai et al., 2011). The outcome of an energy audit provides information about the present energy use of the enterprise and the applied energy saving method. Clearly, energy audit is a necessary step in local construction for defining energy consumption by end use and identifying key areas for energy saving in project site. Virtually, energy audits are an important step for continuous improvement of energy saving activities in local construction sector.

*"Motivate the company employees to apply more onsite energy saving practices" SEM4,* with (MS=4.20, RII=84.47%, SD=0.81 and p-value=0.00) was ranked in the third position of the activities that helping the local contractor to save energy during project construction. Sustainability Victoria (2007) found that, resource efficiency is seen as a change process, and is supported through employee involvement at every stage of project construction. Quite often employees of a company considered as a major impact on energy consumption during on site construction. They are shown as a part of the organizational structure, and are perhaps the greatest untapped resource in an energy management program (Turner and Doty, 2009). However, Ates and Durakbasa (2012) verified that, energy management is not only dependent on the employees' acceptance, but also on their active participation. Therefore, on-site construction employees should be motivated to apply energy saving activities not only making them aware about these activities. So that, energy saving measures can be broadly performed in construction site during execution. In the same line, the involvement and motivation level of employees towards energy management may be translated into positive

practices resulting in more energy saving during construction process. In the line with this result, Sustainability Victoria (2007) reported that motivating people at all levels to behave in a resource conscious manner is the key to achieving energy savings. Kahlenborn et al. (2010) emphasized that, the motivation of all levels and functions employees and the commitment shown for an energy management are of major importance for the long-term success of an energy management. In correlation with the previous result, energy audit which considered as one of the most important activities to save energy can also be considered as one of the most important techniques to achieve higher employees support and participation by communicating periodically to employees regarding cost and progress of energy management (Wai et al., 2011; Vesma, 2012). A systematic approach for involving employees should start with some basic training in energy. Abdelaziz et al. (2011) declared that energy efficiency courses and training programs are very important to increase the awareness and motivation of people who are involved in the industrial sector.

This result suggests that the level of attention given to sustainability and energy issues within the culture, instructions and policies of local construction contractor also have an impact on shaping the attitudes and motivations of the employees of those contractors. As mentioned previously Energy management hasn't applied in local construction sector, which mean that construction workers in these companies are not motivated to apply any techniques or ideas related to energy and sustainability issues during project construction.

*"Selecting where possible only local sources of materials supply" SEM27,* with (MS=3.12, RII=62.37%, SD=0.0.52 and p-value=0.00) was ranked in the position 32 of the listed 33 activities which is the position directly previous to the last activity. Although its importance, this activity comes in a late position because most contractors feel that it will be too hard for the local industry in the short and medium term to make any shift for energy saving from the current situation with major dependence on imports. In addition, several construction materials can't be manufactured locally and major local construction materials manufactured by companies lack environmental responsibility. Actually, there are a shortage of research in the energy efficiency of local construction materials and material alternatives makes it hard to initiate any change to use local martials. However, the importance of this activity emerged as a result of the potential to reuse or recycling some construction materials found in Gaza Strip. On the other hand, using local materials can lessens the dependence on imported construction materials, so that energy saving process can be guaranteed. Enshassi (2000) recommended to examine the potential for the reuse or recycling of construction materials as Gaza Strip has scant economic resources. This finding reinforce the conclusion suggested by Muhaisen and Ahlbäck (2012), which indicated that one of the innovative solutions relating to sustainable construction with potentials in Gaza include increasing the use of local and recycled construction materials in buildings where possible. Akadiri et al. (2012) argued that material from local sources require less processing and therefore, they are less damaging to the environment. In consistent with the previous evidence, Morel et al. (2001) considered the potential for reducing energy consumption during construction by using building techniques suited to locally resourced materials. This study was conducted in Southern France and revealed that by using local materials the amount of energy used in building decreased by up to 215% and the impact of transportation by 453%.

The last position of the proposed activities to save energy was attained by the activity *"Adopting of the available energy code requirements for construction industry" SEM3,* with (MS=3.02, RII=61.58%, SD=0.0.58 and p-value=0.24). Insignificancy of this activity has been discussed previously. However, this lowest energy management activity from the survey analysis contradicts the literature, where energy management code was viewed as an essential element in saving energy and the successful practice of energy management. One of the worldwide examples supporting this tendency was presented by Sheffer and Levitt (2010) who noted that although California state in USA has aggressive green energy codes, energy-saving building technologies implemented by slow mode in this state. Gann et al. (1998) pointed out that codes alone are not enough and do not necessarily increase the rate of diffusion of innovations. The last position of this activity can be justified because introducing energy code requires obvious knowledge, information, experienced individuals and new technologies, material and equipment's, which are not provided and incredibly difficult for local construction contractor. In addition, code officials' in local construction sector have insufficient knowledge about the energy management especially in alternative systems, outdated standards and complexity of compliance systems.

Indeed, local codes of practice in different fields of construction are advisory rather than mandatory. It should be also mentioned that the some energy requirements was prepared as an instructional tool, rather than an obligatory guideline. However, energy codes are almost always more successful when mandatory rather than voluntary. As yet, energy saving technology in Gaza Strip is still at an early stage where specifications have not been established properly. There are misunderstandings on requirements of implementation and operation of energy management. Responsible bodies, which are the engineering association and the local municipalities in Gaza Strip, haven't specified any code requirements related to energy management to give the contractor an approval of project construction. In contrast to this finding, UNEP-SBCI (2009) concluded that building codes have been found to be one of the most effective and cost-effective policies in reducing greenhouse gas emissions. UN Global Compact and Accenture (2012) reported that energy codes for buildings can overcome market barriers that currently restrict research and development investments in improving the energy efficiency of buildings. Furthermore, the development of construction energy codes requires significant technical capacity among government and regulatory agencies. Finally, codes do not solve the cost problem related to energy management system adoption that mentioned in several places of this study.

### 4.7.2 Factor analysis of the best activities to save energy in construction.

With relatively large number of activities for energy saving in construction projects (33 variables) involved in this study, it is possible that some of these activities are measuring aspect of the same underlying effect. In fact, it was advisable to reduce the variables and measure them well, rather than have a large number and not address them properly. Exploratory Factor Analysis was therefore used for data reduction to establish which of the variables (activities) could be measuring aspects of the same underlying dimensions (factors). This study adopted Principle Component Analysis (PCA) to set up which items could capture the aspects of same dimension of the energy saving activities and examine the underlying structure or structure of interrelationships among the 33 activities items. To clarify the factor pattern by ensuring that each variable loaded high on one group factor and very minimal on all other group factors, the variables were 'rotated' using Varimax orthogonal rotation method. As an early step in the data analysis, all questionnaire responses were checked to ensure completeness and readability before the data were processed using the Statistical Package for Social Sciences (SPSS) version 22. In order to perform the factor analysis for proposed items, all the appropriate checks and procedures related to factor analysis were delivered. Three main phases were performed to accomplish factor analysis on the 33 activities for energy saving in construction, as follows:

- **First phase: Preliminary analysis;**
- **Second phase: Factors extraction;**
- **Third phase: Factors naming and interpretation.**

***First phase of factor analysis for energy saving activities: Preliminary analysis.***

Prior to performing factor analysis, the suitability of data for the analysis was assessed. In order to do that, several checks have been performed on the suggested 33 activities for energy saving using the data gathered from study questionnaire filed by respondents. Based on the examination results, factor analysis process were carried out. In this stage, all variables under the study are analyzed together to extract the underlining factors. The tests executed on the 33 activities for energy saving have been described here, as follows:

**1. Type of the study data (variables).**

According to Rehbinder (2011), if the data subjected to a perceptive opinion of the respondents, it can easily used to create reduced number of factors from the multiple variables. Therefore, the data about energy saving activities in this study have been collected by using the ordinal scale. Respondents were asked to indicate their opinions about the effectiveness level of each activity to save energy during project construction by using 5 points-Likert scale. So that, by using Likert scale with ordinal level of measurement in this part, the data related to these 33 satisfied its suitability for factor analysis according to Yong and Pearce (2013).

**2. Distribution of the data**

With the base of Central Limit Theorem, the data collected about energy management adoption barriers can be considered normally distributed because sample size for this study was 76 which was larger than 30 as proposed by Hair et al. (2010). Therefore, the normal distribution requirement for factor analysis application for this part of study has been satisfied as stipulated by (Field, 2009).

**3. Sample size**

For factor analysis, Tabachnick and Fidell (2007) and Hair et al. (2010) recommend having at least 5 cases for each item is adequate in most cases. In this part, this factor analysis contains in total 76 respondents and 33 variables (activities), which means that the analysis has 76/33 = 2.30 respondents per variable which is less than 5. One can therefore conclude that the sample size is limited compared to the number of variables. It was however not possible to collect more data or respondents because of time restrictions, and the analysis had to continue with a sample size of 76. Actually, 76 respondents have been obtained in this study. This number is larger than 50. Therefore, the sample size in this study can be considered adequate for factor analysis based on de Winter et al. (2009) and Sapnas and Zeller (2002).

**4. Data reliability test.**

The first stage of the quantitative analysis was related to the reliability test where the reliability of the questionnaire was tested according to the Cronbach's alpha measurement. Therefore, to decide the reliability (internal consistency) of the 33 items (activities), Table (4.34) shows that, Cronbach coefficient alpha equals 0.82, which is considered acceptable (> 0.7) according to Pallant (2005). Additionally, the final solution for factor analysis included only 27 variables (activities) satisfied all factor analysis and its Cronbach coefficient alpha equals 0.80. Due to these high coefficient values of Cronbach's alpha, it can be concluded that the respondents were admitted the effectiveness of these activities for energy saving in construction. So that, by validating the reliability of the data, other checks and processes of factor analysis can be performed.

**5. Factorability of the correlation matrix.**

Field (2009) asserted that, the correlation matrix for the included items should be generated and checked to investigate the variables correlations together in which the variables should not correlate too highly or too lowly with other variables. Tabachnick and Fidell (2007) and Field (2009) recommended that, if there are some correlations above 0.3 and none of these are greater than 0.9, it is valid to carrying on with the analysis. In general, if the visual inspection of the correlation matrix revealed no substantial number of correlations greater than 0.30, then the factor analysis may probably inappropriate (Hair et al., 2010). Therefore, this check aimed to assess the factorability of the correlation matrix via the visual inspection of the energy saving activities correlation matrix. Therefore, inspection of the correlation matrix in Table (4.32) revealed that each one of the included activities (variables) correlated with some other activities with a correlation coefficient greater than 0.30 at the 0.01 level of significance which viewed in bold line in the table. This results indicated that a patterned relationship can be found amongst the 33 activities (variables). In general, These values of the correlation coefficients for energy saving activities showed an adequate correlation amongst several variables. For example, the activity *SEM1* has some correlation with 8 variables *SEM2*, *SEM3*, *SEM8*, *SEM9*, *SEM12*, *SEM14*, *SEM17* and *SEM 26* with a correlation coefficients equal to 0.52, 0.47, 0.41, 0.57, 0.45, 0.41, 0.37 and 0.49, respectively. The values of these coefficients are larger than 0.3 and smaller than 0.9, so that, the variable *SEM1* should be retained in further analysis as it has a considerable relationship with others in study. Each one of the 33 variables included in the correlation matrix was checked as described above for *SEM1*. This result provides an adequate basis for proceeding to the next level, the empirical examination of the adequacy for factor analysis. The correlation matrix for the final solution involved the remaining 27 variables (activities) can be shown in Table (E.9) of Appendix E.

6. **Items Correlation Matrix Adequacy *"Kaiser-Meyer-Olkin (KMO) Measure of Sampling Adequacy/Bartlett's Test of Sphericity"***

The first part of this check was performed to examine the anti-image correlation matrix; the diagonals on that specific matrix should have Measure of Sampling Adequacy (MSA) of 0.50 or above (Field, 2009). By looking at the bolded diagonal elements in the anti-image correlation matrix provided in Table (4.33), it can be seen that all variables (activities) in this matrix with MSA values higher than 0.5 with highest value equals to 0.84 for *SEM31* and lowest value of 0.57 for *SEM17*. In addition, for example the MSA values for the variables *SEM1*, *SEM7*, *SEM15*, *BEM23* equals 0.73, 0.74, 0.62 and 0.865, respectively, which are larger than 0.5. Therefore the all these variables exhibited satisfactory values were deemed fit for further analysis. It is worth noting that, the diagonal of the anti-image correlation matrix should be investigated in each run when factor analysis process repeated. Table (E.10) in appendix E stipulates anti-image correlation matrix for the final solution which involved the remaining 27 variables (activities). From this table, it can be seen that each one of the involved items\variables in final solution has MSA value larger than 0.5 and hence, MSA threshold requirement was satisfied.

Moreover, Kaiser-Meyer-Olkin (KMO) and Bartlett's test have been employed to assess the appropriateness of the factor analysis process. Kaiser Meyer Olkin (KMO) statistic compares the magnitude of observed correlation coefficients with the magnitude of partial correlation coefficient. However, significance of correlation matrix is established using Bartlett's test of sphericity. Mane and Nagesha (2014) pinpointed that, the Bartlett's test of sphericity is significant when (p-value <0.05), and when the value of the KMO index is above 0.5, suggesting the data set is suitable for factor analysis. In the first run all the 33 activities (variables) for energy saving were included and Table (4.34) shows the KMO value for these activities at 0.69 (should be > 0.50), and the Bartlett's test for sphericity at p-value= 0.00 level (Should be < 0.05). Hence, both of these two tests on the initial data of the 33 variables (activities) meeting the requirements and showed that the items in the scale were suitable for factor analysis.

After performing factor extraction and rotation on these 33 variables (activities), other criteria for factor analysis may justify the elimination of any variable from the proposed list before moving to the next run. Kaiser Meyer Olkin (KMO) test and the Bartlett test of sphericity have been performed in each run of factor analysis when any variable removed from analysis. On the basis of such results it was deemed fit to proceed with conducting the principle factor analysis using the remaining variables in each run. For this part of study, the results obtained from the final run test revealed that all the remaining variables has good sample adequacy. The KMO test gave the value of 0.72 and the Bartlett test of sphericity reached statistical significance with (Chi-square 1310.24) and significance level of (p-value 0.00).

Table (4.32): Correlation matrix for best activities to save energy

| | SEM1 | SEM2 | SEM3 | SEM4 | SEM5 | SEM6 | SEM7 | SEM8 | SEM9 | SEM10 | SEM11 | SEM12 | SEM13 | SEM14 | SEM15 | SEM16 | SEM17 | SEM18 | SEM19 | SEM20 | SEM21 | SEM22 | SEM23 | SEM24 | SEM25 | SEM26 | SEM27 | SEM28 | SEM29 | SEM30 | SEM31 | SEM32 | SEM33 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SEM1 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| SEM2 | **0.52** | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| SEM3 | **0.47** | 0.34 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| SEM4 | 0.02 | -0.01 | 0.05 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| SEM5 | 0.04 | -0.04 | -0.05 | -0.09 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| SEM6 | **0.37** | **0.52** | **0.50** | 0.01 | 0.00 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| SEM7 | -0.01 | 0.03 | -0.18 | -0.09 | **0.50** | -0.16 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | |
| SEM8 | **0.41** | **0.53** | 0.43 | 0.05 | -0.01 | **0.41** | -0.23 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | |
| SEM9 | **0.57** | **0.39** | 0.53 | 0.05 | -0.12 | **0.42** | -0.16 | **0.37** | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | |
| SEM10 | -0.18 | 0.00 | -0.01 | 0.39 | -0.10 | 0.07 | 0.01 | -0.04 | -0.01 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | |
| SEM11 | -0.01 | -0.01 | -0.06 | -0.03 | **0.71** | 0.07 | **0.33** | 0.07 | -0.13 | -0.09 | 1.00 | | | | | | | | | | | | | | | | | | | | | | |
| SEM12 | **0.45** | **0.46** | **0.37** | -0.01 | -0.04 | **0.44** | 0.01 | **0.33** | **0.43** | 0.09 | 0.01 | 1.00 | | | | | | | | | | | | | | | | | | | | | |
| SEM13 | 0.03 | -0.07 | -0.12 | -0.07 | **0.53** | -0.18 | **0.57** | 0.11 | -0.24 | -0.07 | **0.42** | -0.06 | 1.00 | | | | | | | | | | | | | | | | | | | | |
| SEM14 | **0.41** | **0.33** | **0.51** | -0.10 | -0.07 | 0.39 | -0.23 | **0.35** | **0.48** | -0.13 | -0.01 | **0.40** | -0.07 | 1.00 | | | | | | | | | | | | | | | | | | | |
| SEM15 | -0.06 | -0.05 | 0.03 | **0.76** | -0.09 | 0.08 | -0.02 | 0.02 | 0.08 | **0.58** | 0.04 | 0.04 | -0.06 | -0.13 | 1.00 | | | | | | | | | | | | | | | | | | |
| SEM16 | -0.12 | -0.12 | 0.03 | **0.60** | -0.03 | 0.02 | 0.03 | -0.03 | -0.04 | **0.59** | 0.06 | -0.02 | -0.05 | -0.25 | **0.58** | 1.00 | | | | | | | | | | | | | | | | | |
| SEM17 | **0.37** | **0.39** | **0.41** | -0.03 | 0.13 | **0.47** | -0.04 | **0.32** | **0.34** | -0.02 | 0.14 | **0.35** | -0.02 | **0.36** | 0.03 | -0.05 | 1.00 | | | | | | | | | | | | | | | | |
| SEM18 | -0.05 | -0.04 | 0.16 | **0.54** | -0.09 | 0.17 | -0.01 | 0.12 | 0.07 | **0.56** | 0.02 | 0.09 | -0.06 | -0.04 | **0.64** | **0.64** | -0.07 | 1.00 | | | | | | | | | | | | | | | |
| SEM19 | -0.01 | -0.01 | 0.05 | **0.54** | -0.10 | 0.26 | -0.09 | 0.02 | 0.17 | **0.59** | 0.06 | 0.18 | -0.11 | -0.05 | **0.73** | **0.50** | 0.10 | **0.67** | 1.00 | | | | | | | | | | | | | | |
| SEM20 | -0.08 | -0.04 | 0.04 | **0.56** | -0.11 | 0.10 | 0.02 | 0.02 | 0.00 | **0.79** | -0.10 | 0.13 | -0.04 | -0.21 | **0.65** | **0.79** | -0.04 | **0.59** | **0.55** | 1.00 | | | | | | | | | | | | | |
| SEM21 | 0.19 | 0.08 | 0.19 | -0.06 | 0.26 | 0.07 | 0.00 | 0.18 | 0.14 | -0.06 | 0.20 | -0.04 | 0.12 | 0.14 | -0.05 | 0.02 | 0.05 | 0.06 | 0.02 | -0.10 | 1.00 | | | | | | | | | | | | |
| SEM22 | 0.14 | 0.13 | 0.13 | -0.06 | 0.16 | 0.04 | 0.04 | 0.10 | 0.09 | 0.14 | 0.14 | 0.08 | -0.05 | 0.11 | 0.00 | 0.02 | 0.17 | 0.05 | 0.05 | 0.02 | **0.65** | 1.00 | | | | | | | | | | | |
| SEM23 | 0.02 | -0.01 | 0.06 | -0.01 | 0.09 | -0.05 | 0.07 | -0.15 | -0.09 | 0.22 | 0.16 | 0.10 | 0.08 | 0.10 | -0.02 | 0.10 | -0.08 | 0.01 | 0.16 | 0.09 | **0.41** | 0.52 | 1.00 | | | | | | | | | | |
| SEM24 | -0.10 | 0.01 | 0.09 | 0.12 | 0.04 | 0.11 | -0.05 | 0.01 | -0.07 | 0.21 | 0.13 | 0.00 | -0.04 | 0.03 | 0.13 | 0.12 | -0.05 | 0.06 | 0.19 | 0.14 | **0.48** | 0.63 | **0.71** | 1.00 | | | | | | | | | |
| SEM25 | -0.07 | -0.06 | 0.01 | -0.07 | **0.77** | -0.02 | **0.59** | -0.06 | -0.17 | -0.10 | **0.57** | -0.04 | **0.56** | -0.06 | -0.02 | 0.03 | -0.04 | -0.03 | -0.06 | -0.08 | 0.20 | 0.12 | 0.19 | 0.18 | 1.00 | | | | | | | | |
| SEM26 | **0.49** | **0.47** | **0.40** | 0.05 | -0.06 | **0.48** | -0.17 | **0.34** | **0.52** | -0.08 | -0.06 | **0.68** | -0.23 | **0.32** | 0.14 | -0.15 | **0.33** | -0.08 | 0.10 | -0.03 | 0.05 | 0.03 | -0.08 | 0.05 | -0.12 | 1.00 | | | | | | | |
| SEM27 | 0.02 | -0.03 | 0.10 | -0.06 | 0.16 | 0.05 | 0.14 | -0.19 | -0.03 | 0.20 | 0.04 | 0.06 | 0.10 | 0.11 | 0.03 | -0.06 | -0.11 | 0.08 | 0.15 | 0.00 | **0.46** | **0.42** | **0.50** | **0.48** | 0.20 | -0.02 | 1.00 | | | | | | |
| SEM28 | 0.21 | 0.14 | 0.17 | 0.05 | 0.16 | 0.27 | 0.01 | 0.02 | 0.17 | 0.20 | 0.08 | 0.10 | -0.01 | 0.16 | 0.02 | 0.23 | 0.09 | 0.14 | 0.11 | 0.23 | **0.48** | **0.59** | **0.58** | **0.47** | 0.13 | 0.00 | **0.36** | 1.00 | | | | | |
| SEM29 | 0.03 | 0.01 | 0.17 | -0.07 | 0.08 | 0.08 | -0.03 | -0.16 | 0.18 | 0.19 | 0.03 | -0.04 | -0.11 | 0.19 | -0.07 | -0.01 | -0.09 | 0.04 | 0.15 | 0.00 | **0.38** | **0.40** | **0.59** | **0.47** | 0.13 | -0.07 | **0.58** | **0.60** | 1.00 | | | | |
| SEM30 | -0.03 | 0.00 | -0.01 | -0.14 | **0.62** | -0.03 | **0.64** | -0.07 | -0.18 | -0.03 | **0.53** | 0.00 | **0.50** | -0.07 | -0.16 | 0.04 | 0.02 | -0.05 | -0.09 | -0.03 | 0.05 | 0.15 | 0.25 | 0.23 | **0.75** | -0.16 | 0.22 | 0.18 | 0.21 | 1.00 | | | |
| SEM31 | -0.02 | 0.00 | 0.00 | -0.16 | **0.58** | -0.07 | **0.74** | -0.08 | -0.17 | -0.08 | **0.43** | -0.01 | **0.58** | -0.09 | -0.15 | -0.02 | 0.02 | -0.04 | -0.24 | -0.06 | 0.04 | 0.12 | 0.10 | 0.08 | **0.67** | -0.17 | 0.18 | 0.12 | 0.05 | **0.79** | 1.00 | | |
| SEM32 | 0.00 | 0.00 | -0.18 | -0.16 | **0.44** | 0.03 | **0.40** | 0.01 | -0.14 | -0.12 | **0.54** | -0.07 | **0.46** | -0.06 | -0.06 | -0.09 | 0.01 | -0.12 | -0.09 | -0.09 | 0.23 | -0.02 | 0.08 | 0.08 | **0.43** | -0.11 | 0.20 | 0.02 | -0.02 | **0.40** | **0.38** | 1.00 | |
| SEM33 | -0.09 | -0.07 | 0.21 | 0.41 | -0.01 | 0.12 | 0.03 | 0.04 | -0.04 | **0.34** | 0.19 | 0.03 | 0.01 | -0.01 | **0.49** | **0.56** | -0.11 | 0.70 | **0.53** | **0.44** | -0.02 | -0.12 | -0.02 | 0.00 | 0.10 | -0.04 | -0.14 | -0.04 | -0.07 | 0.02 | -0.02 | -0.11 | 1.00 |

Table (4.33): Anti-image correlation matrix for best activities to save energy

| | SEM1 | SEM2 | SEM3 | SEM4 | SEM5 | SEM6 | SEM7 | SEM8 | SEM9 | SEM10 | SEM11 | SEM12 | SEM13 | SEM14 | SEM15 | SEM16 | SEM17 | SEM18 | SEM19 | SEM20 | SEM21 | SEM22 | SEM23 | SEM24 | SEM25 | SEM26 | SEM27 | SEM28 | SEM29 | SEM30 | SEM31 | SEM32 | SEM33 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SEM1 | **0.81**[a] | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| SEM2 | -0.23 | **0.73**[a] | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| SEM3 | -0.16 | 0.16 | **0.68**[a] | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| SEM4 | -0.10 | -0.22 | -0.07 | **0.73**[a] | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| SEM5 | -0.09 | 0.16 | 0.08 | -0.26 | **0.64**[a] | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| SEM6 | -0.04 | -0.25 | -0.21 | 0.10 | 0.13 | **0.61**[a] | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| SEM7 | -0.01 | -0.28 | 0.15 | 0.08 | -0.13 | -0.07 | **0.74**[a] | | | | | | | | | | | | | | | | | | | | | | | | | | |
| SEM8 | -0.01 | -0.42 | -0.22 | 0.06 | -0.03 | -0.09 | 0.35 | **0.64**[a] | | | | | | | | | | | | | | | | | | | | | | | | | |
| SEM9 | -0.25 | 0.05 | -0.32 | 0.05 | 0.03 | 0.07 | -0.20 | -0.06 | **0.73**[a] | | | | | | | | | | | | | | | | | | | | | | | | |
| SEM10 | 0.23 | -0.24 | 0.05 | 0.27 | -0.22 | -0.05 | 0.05 | 0.03 | -0.05 | **0.75**[a] | | | | | | | | | | | | | | | | | | | | | | | |
| SEM11 | 0.06 | -0.02 | 0.10 | 0.13 | -0.61 | -0.21 | 0.24 | -0.03 | -0.03 | 0.11 | **0.59**[a] | | | | | | | | | | | | | | | | | | | | | | |
| SEM12 | 0.03 | -0.03 | 0.04 | -0.09 | 0.22 | 0.07 | -0.13 | -0.08 | -0.05 | 0.04 | -0.20 | **0.58**[a] | | | | | | | | | | | | | | | | | | | | | |
| SEM13 | -0.17 | 0.21 | 0.09 | -0.08 | 0.05 | 0.21 | -0.29 | -0.42 | 0.14 | -0.11 | -0.10 | 0.02 | **0.72**[a] | | | | | | | | | | | | | | | | | | | | |
| SEM14 | -0.04 | 0.04 | 0.00 | -0.09 | 0.05 | -0.11 | 0.20 | -0.06 | -0.30 | -0.08 | 0.04 | -0.25 | -0.08 | **0.75**[a] | | | | | | | | | | | | | | | | | | | |
| SEM15 | 0.01 | 0.08 | -0.01 | -0.53 | 0.37 | 0.27 | -0.17 | -0.03 | 0.00 | -0.18 | -0.34 | 0.44 | 0.08 | -0.10 | **0.62**[a] | | | | | | | | | | | | | | | | | | |
| SEM16 | -0.02 | 0.08 | 0.07 | -0.30 | 0.24 | 0.09 | -0.01 | 0.03 | -0.11 | -0.06 | -0.23 | 0.07 | 0.19 | 0.18 | 0.16 | **0.76**[a] | | | | | | | | | | | | | | | | | |
| SEM17 | 0.05 | -0.13 | -0.39 | 0.12 | -0.26 | -0.25 | 0.00 | 0.13 | 0.15 | 0.01 | 0.05 | -0.12 | -0.12 | -0.23 | -0.19 | -0.23 | **0.57**[a] | | | | | | | | | | | | | | | | |
| SEM18 | 0.01 | 0.11 | -0.03 | -0.05 | -0.07 | -0.10 | -0.02 | -0.25 | 0.03 | -0.14 | 0.13 | -0.23 | 0.13 | 0.01 | -0.22 | -0.20 | 0.20 | **0.79**[a] | | | | | | | | | | | | | | | |
| SEM19 | -0.04 | 0.14 | 0.35 | -0.03 | -0.04 | -0.35 | 0.11 | 0.03 | -0.30 | -0.08 | 0.10 | -0.20 | -0.11 | 0.30 | -0.40 | 0.10 | -0.26 | -0.18 | **0.70**[a] | | | | | | | | | | | | | | |
| SEM20 | -0.07 | 0.10 | -0.12 | 0.01 | -0.17 | -0.07 | 0.00 | -0.07 | 0.07 | -0.52 | 0.28 | -0.30 | -0.07 | 0.13 | -0.27 | -0.49 | 0.17 | 0.19 | 0.05 | **0.73**[a] | | | | | | | | | | | | | |
| SEM21 | 0.01 | -0.03 | -0.06 | 0.04 | -0.20 | 0.11 | -0.02 | -0.15 | -0.12 | 0.16 | 0.11 | 0.21 | -0.18 | 0.02 | 0.13 | -0.25 | 0.01 | -0.08 | -0.02 | 0.10 | **0.69**[a] | | | | | | | | | | | | |
| SEM22 | -0.15 | -0.02 | 0.04 | 0.13 | 0.10 | 0.35 | -0.17 | -0.12 | 0.02 | -0.18 | -0.22 | -0.12 | 0.32 | 0.03 | -0.03 | 0.18 | -0.27 | -0.05 | -0.01 | 0.03 | -0.42 | **0.62**[a] | | | | | | | | | | | |
| SEM23 | -0.19 | -0.07 | -0.21 | 0.07 | 0.13 | 0.37 | -0.13 | 0.12 | 0.24 | -0.18 | -0.20 | -0.26 | -0.05 | -0.10 | 0.11 | -0.06 | 0.06 | 0.12 | -0.23 | 0.12 | -0.02 | 0.17 | **0.65**[a] | | | | | | | | | | |
| SEM24 | 0.28 | 0.11 | 0.07 | -0.25 | 0.15 | -0.34 | 0.15 | -0.10 | 0.01 | 0.05 | 0.04 | 0.23 | 0.03 | 0.04 | 0.00 | 0.06 | 0.08 | 0.09 | 0.05 | -0.12 | -0.11 | -0.44 | -0.57 | **0.65**[a] | | | | | | | | | |
| SEM25 | 0.17 | -0.05 | -0.14 | 0.18 | -0.61 | -0.22 | -0.01 | 0.05 | 0.02 | 0.19 | 0.28 | -0.21 | -0.17 | -0.05 | -0.41 | -0.19 | 0.31 | 0.17 | 0.05 | 0.18 | -0.05 | -0.07 | -0.09 | -0.03 | **0.70**[a] | | | | | | | | |
| SEM26 | -0.15 | -0.12 | -0.04 | 0.18 | -0.27 | -0.17 | 0.11 | 0.04 | -0.15 | 0.07 | 0.17 | -0.68 | 0.08 | 0.18 | -0.50 | 0.03 | 0.10 | 0.28 | 0.17 | 0.15 | -0.16 | 0.15 | 0.14 | -0.26 | 0.21 | **0.61**[a] | | | | | | | |
| SEM27 | -0.06 | -0.03 | -0.26 | 0.09 | -0.14 | -0.14 | 0.04 | 0.32 | 0.29 | -0.12 | 0.18 | -0.19 | -0.14 | -0.13 | -0.16 | -0.02 | 0.30 | -0.12 | -0.12 | 0.14 | -0.27 | -0.10 | 0.02 | -0.08 | 0.14 | 0.07 | **0.63**[a] | | | | | | |
| SEM28 | -0.04 | -0.03 | 0.17 | 0.02 | -0.21 | -0.48 | 0.20 | 0.16 | -0.06 | 0.25 | 0.21 | 0.01 | -0.17 | -0.03 | -0.12 | -0.16 | 0.08 | -0.10 | 0.20 | -0.22 | -0.09 | -0.41 | -0.39 | 0.22 | 0.15 | 0.05 | 0.19 | **0.62**[a] | | | | | |
| SEM29 | 0.09 | -0.05 | -0.08 | -0.05 | 0.10 | 0.15 | -0.01 | 0.04 | -0.26 | -0.18 | -0.13 | 0.21 | 0.19 | -0.06 | 0.17 | 0.15 | 0.04 | 0.02 | -0.14 | 0.03 | -0.04 | 0.18 | -0.13 | -0.01 | -0.10 | -0.03 | -0.36 | -0.42 | **0.72**[a] | | | | |
| SEM30 | -0.11 | -0.01 | -0.04 | -0.04 | 0.07 | 0.23 | -0.18 | -0.12 | 0.11 | -0.01 | -0.21 | 0.11 | 0.08 | -0.06 | 0.35 | -0.10 | -0.09 | -0.02 | -0.25 | -0.06 | 0.29 | 0.04 | 0.13 | -0.23 | -0.38 | -0.11 | -0.05 | -0.08 | -0.14 | **0.77**[a] | | | |
| SEM31 | 0.07 | 0.01 | -0.12 | 0.04 | -0.02 | -0.04 | -0.33 | 0.07 | -0.06 | 0.01 | -0.03 | -0.02 | -0.22 | 0.06 | -0.07 | 0.04 | -0.02 | -0.18 | 0.29 | 0.02 | 0.12 | -0.06 | 0.08 | -0.06 | -0.03 | 0.03 | -0.09 | -0.08 | 0.07 | -0.42 | **0.84**[a] | | |
| SEM32 | -0.05 | -0.01 | 0.15 | 0.12 | 0.16 | -0.07 | -0.16 | -0.03 | -0.03 | 0.06 | -0.41 | 0.04 | -0.02 | -0.04 | -0.06 | 0.12 | -0.04 | 0.00 | 0.04 | -0.19 | -0.31 | 0.31 | 0.03 | -0.07 | -0.06 | 0.08 | -0.17 | -0.01 | 0.13 | -0.07 | 0.03 | **0.72**[a] | |
| SEM33 | 0.05 | -0.11 | -0.40 | 0.12 | 0.09 | 0.02 | -0.11 | 0.22 | 0.30 | 0.08 | -0.27 | 0.11 | -0.08 | -0.27 | 0.06 | -0.16 | 0.29 | -0.41 | -0.32 | -0.08 | -0.13 | 0.05 | 0.06 | -0.01 | -0.06 | -0.13 | 0.34 | 0.10 | -0.01 | 0.05 | 0.03 | 0.15 | **0.65**[a] |

Table (4.34): KMO and Bartlett's test for energy saving activities

KMO and Bartlett's Test

| Item | | Factor analysis run description | |
|---|---|---|---|
| | | First Run | Final Run "Seventh run" |
| Number of included variables | | 33 | 27 |
| Number of extracted factors | | 6 | 5 |
| Kaiser-Meyer-Olkin Measure of Sampling Adequacy. | | 0.69 | 0.72 |
| Bartlett's Test of Sphericity | Approx. Chi-Square | 1687.16 | 1310.24 |
| | df | 523 | 351 |
| | Sig. | 0.00 | 0.00 |
| Cronbach's alpha | | 0.82 | 0.80 |

## ***Second phase of factor analysis or energy saving activities: Factors extraction***

Once the number of the variable to be included in factor analysis identified. It is required to decide how many factors are to be extracted from the given set of data. To examine which variable significantly contribute to factors, the PCA was applied with varimax rotation to validate which constructs to be distinct as perceived by the respondents. Varimax rotation minimizes the number of variables that have high loadings on any one given factor. In this study, Kaiser's criterion was used with eigenvalues equal to or greater than unity, in order to establish the number of extraction factors (Tabachnick and Fidell, 2007). In addition, Scree plot was used for validation only. Therefore, the first run of factor analysis has included all the 33 activities to save energy because it have satisfied all the primary tests before extractions. Consequently, in the first run, the rule of an eigenvalue greater than one extracts 7 components , as shown in Table (4.35). To obtain interpretable results for those seven factors, a varimax rotation was then performed. Scree plot for the final runs of factor analysis has presented in Figure (4.10) below. From this figure it is clear that a break after the fourth component in the final solution. Several criteria should be achieved in order to accept the extracted solution obtained in any run of factor analysis and to consider this solution as the final solution for the involved variables. The following sections explains these criteria and process of investigation.

1. **Communality values**

Communality is the first criteria to be checked in the extracted solution. Therefore, factor analysis communality table results were examined to validate communalities of the data involved in the solution to be more than 0.5 as specified by several researchers. The communality is defined as the percentage of variance in a particular variable that is explained by the factor (Williams et al., 2010). Extraction communalities are estimates of the variance in each variables accounted for by the factors or components in the factor solution. Higher communality value means higher importance of the variables. The general guidelines mentioned that the factor solution explain at least half of each original variable's variance, thus the communality value (score after extraction) should be more than 0.5 point for the data to be justifiable for application of the factor analysis method (Field, 2009). Communalities less than 0.5 were considered too low, since this would meant the variable share less than half of its variability with other variables (Larose, 2006). Thus, variables with loadings less than 0.5 were removed from the analysis due to low communality. The analysis revealed that the values of extracted communalities for all factors in the first run were higher than 0.5 except the variable *"Employing a specialized team or person responsible for all energy issues during onsite works" SEM17*, with communality value equals to 0.44. So that, the activity *SEM17* should be removed and factor analysis should be repeated in the second run with only the remaining 32 variables. After omitting the above variable, the communality values was then investigated again, to check the revised communality values for remaining variables. In addition, each time in which the data changed, this test should be repeated to check the communality values so that its requirements should be satisfied before proceeding to the next checks on the emerged solution. Therefore, variables with communalities less than 0.5 were suppressed and removed from the analysis due to a low communality. The final run communality values confirms with this assumption as their values larger than 0.5 as shown in Table (4.35). Accordingly, the data set remaining in the final solution can be considered justifiable for the acceptance of factor analysis results.

Table (4.35) : Communality values of best activities to save energy
"First run & Final run"

| Item | Extraction | |
|---|---|---|
| | First Run | Final Run "Seventh run" |
| SEM1 | 0.58 | 0.62 |
| SEM2 | 0.62 | 0.57 |
| SEM3 | 0.73 | Removed in $7^{th}$ run |
| SEM4 | 0.60 | 0.58 |
| SEM5 | 0.73 | 0.64 |
| SEM6 | 0.57 | 0.54 |
| SEM7 | 0.76 | 0.67 |
| SEM8 | 0.67 | Removed in $4^{th}$ run |
| SEM9 | 0.59 | 0.58 |
| SEM10 | 0.72 | 0.62 |
| SEM11 | 0.73 | Removed in $3^{ed}$ run |
| SEM12 | 0.69 | 0.59 |
| SEM13 | 0.59 | 0.60 |
| SEM14 | 0.62 | Removed in $6^{th}$ run |
| SEM15 | 0.80 | 0.80 |
| SEM16 | 0.79 | 0.80 |
| SEM17 | 0.44 | Removed in $2^{ed}$ run |

Table (4.35) : Communality values of best activities to save energy "First run & Final run". "Continued"

| Item | Extraction | |
|---|---|---|
| | First Run | Final Run "Seventh run" |
| SEM18 | 0.77 | 0.70 |
| SEM19 | 0.79 | 0.78 |
| SEM20 | 0.84 | 0.76 |
| SEM21 | 0.75 | Removed in 5ed run |
| SEM22 | 0.74 | 0.60 |
| SEM23 | 0.69 | 0.71 |
| SEM24 | 0.69 | 0.70 |
| SEM25 | 0.78 | 0.76 |
| SEM26 | 0.72 | 0.73 |
| SEM27 | 0.65 | 0.65 |
| SEM28 | 0.70 | 0.76 |
| SEM29 | 0.75 | 0.63 |
| SEM30 | 0.80 | 0.77 |
| SEM31 | 0.83 | 0.79 |
| SEM32 | 0.59 | 0.52 |
| SEM33 | 0.75 | 0.54 |

*Extraction Method: Principal Component Analysis.*
*Items were removed during several runs of factor analysis.*

**2. Cumulative percentage of variance explained by the extracted factor solution.**

By determining total variance explained the number of the significant factors can be determined. Table (4.36) shows the total variance explained for all variables in the first run solution. The results showed that there were seven components with eigenvalue greater than 1. Thus, these seven components\factors have been extracted for these variables which would explain 69.88% of the total variance, which is greater than the threshold of 50% total variance explained (Meyers et al., 2006; Mane and Nagesha, 2014). This value of the cumulative percentage of variance explained meaning that a considerable amount of the common variance shared by the 33 variables could be accounted for by these seven factors (De Vaus, 2002). The value of total variance explained by component 1 to component 7 were 15.81%, 15.00%, 14.49%, 12.85%, 4.03%, 3.86%, and 3.84%, respectively. Factor importance increased if the variance explained by it increased. Thus, the first component is the most important factor as it explains the most variance of the data. However, the total variance explained by the final run of factor analysis on energy saving activities was 62.91% and including four factors extracted from the remaining 27 variables as shown in Table (E. 11) in Appendix E.

Table (4.36): Total variance explained by factor analysis for the first run on best activities to save energy

| Component | Initial Eigenvalues | | | Extraction Sums of Squared Loadings | | | Rotation Sums of Squared Loadings | | |
|---|---|---|---|---|---|---|---|---|---|
| | Total | % of Variance | Cumulative % | Total | % of Variance | Cumulative % | Total | % of Variance | Cumulative % |
| 1 | 5.73 | 17.36 | 17.36 | 5.73 | 17.36 | 17.36 | 5.22 | 15.81 | 15.81 |
| 2 | 5.27 | 15.97 | 33.33 | 5.27 | 15.97 | 33.33 | 4.95 | 15.00 | 30.81 |
| 3 | 5.04 | 15.27 | 48.60 | 5.04 | 15.27 | 48.60 | 4.78 | 14.49 | 45.30 |
| 4 | 3.40 | 10.31 | 58.91 | 3.40 | 10.31 | 58.91 | 4.24 | 12.85 | 58.14 |
| 5 | 1.34 | 4.07 | 62.98 | 1.34 | 4.07 | 62.98 | 1.33 | 4.03 | 62.17 |
| 6 | 1.18 | 3.56 | 66.54 | 1.18 | 3.56 | 66.54 | 1.27 | 3.86 | 66.04 |
| 7 | 1.10 | 3.34 | 69.88 | 1.10 | 3.34 | 69.88 | 1.27 | 3.84 | 69.88 |
| 8 | 0.97 | 2.95 | 72.83 | | | | | | |
| 9 | 0.88 | 2.67 | 75.50 | | | | | | |
| 10 | 0.87 | 2.64 | 78.14 | | | | | | |
| 11 | 0.74 | 2.23 | 80.37 | | | | | | |
| 12 | 0.71 | 2.14 | 82.51 | | | | | | |
| 13 | 0.67 | 2.03 | 84.55 | | | | | | |
| 14 | 0.59 | 1.78 | 86.33 | | | | | | |
| 15 | 0.56 | 1.70 | 88.03 | | | | | | |
| 16 | 0.49 | 1.49 | 89.52 | | | | | | |
| 17 | 0.45 | 1.35 | 90.87 | | | | | | |
| 18 | 0.43 | 1.29 | 92.16 | | | | | | |
| 19 | 0.38 | 1.14 | 93.30 | | | | | | |
| 20 | 0.31 | 0.93 | 94.24 | | | | | | |
| 21 | 0.28 | 0.86 | 95.10 | | | | | | |
| 22 | 0.24 | 0.72 | 95.82 | | | | | | |
| 23 | 0.23 | 0.70 | 96.51 | | | | | | |
| 24 | 0.17 | 0.53 | 97.04 | | | | | | |
| 25 | 0.17 | 0.51 | 97.55 | | | | | | |
| 26 | 0.15 | 0.46 | 98.02 | | | | | | |
| 27 | 0.13 | 0.39 | 98.41 | | | | | | |
| 28 | 0.12 | 0.37 | 98.78 | | | | | | |
| 29 | 0.11 | 0.34 | 99.12 | | | | | | |
| 30 | 0.09 | 0.28 | 99.41 | | | | | | |
| 31 | 0.08 | 0.25 | 99.66 | | | | | | |
| 32 | 0.07 | 0.21 | 99.86 | | | | | | |
| 33 | 0.05 | 0.14 | 100.00 | | | | | | |

Extraction Method: Principal Component Analysis

3. **Loaded items and extracted factors properties.**

When all requirements mentioned in previous sections are satisfied, Varimax rotation method should be applied on the extracted factors leading to rotated component matrix table, which is the most important table of factor analysis as it involves and summarizes the solution need by providing the extracted factors and items loaded on each factor. This matrix should be checked and examined for three main conditions to be achieved. As discussed earlier about the first run of the 33 activities for energy saving, seven factors\components can interpret these 33 items in each one of these components some correlated variables are involved. Table (4.37) shows the rotated component matrix for the first run solution. It is worth noting that this table provided here for explanation only for the procedures for testing this matrix when obtained in the each run follows the first run and the criteria to accept this table contents. Three examination types have been conducted on this table to satisfy the proposed three conditions requirements, as follows;

**<u>First condition:</u> Each item should has at least one factor loading value equal or more than (0.5).**

This condition requires to check the rotated component matrix to insure that each item\variable has at least one factor loading greater than 0.5 meaning that each item should be loaded on one factor at least with factor loading more than 0.5. If any item don't include any factor loading more than 0.5, it should be removed from analysis. Therefore, on the basis of this condition, only items with factor loading equal or above 0.5 are shown in Table (4.37). So that, eight items loaded on the first factor, eight items loaded on the second factor, ten items loaded on the third factor seven items loaded on the fourth factor and each one of the fifth, sixth and seventh factors had one item only. Consequently, each item of the 33 items (activities) had at least one factor lading greater than 0.5 which mean that each one of these items can be loaded at least on one factor of the extracted factors. on this basis only, all the 33 items should be remained in interpreting acceptable solution.

**<u>Second condition:</u> Each one of the extracted factors should include at least three items to be acceptable.**

This condition involve requirement needed to be sure that, each factor from the extracted factors should have at least 3 items, when the factor doesn't satisfy this requirement it should be removed from analysis by removing the involved items. Again, the factors in Table (4.37) were then examined to identify the number of items that loaded on each factor by keeping in mind that factors with fewer than three items is generally weak and unstable (Costello and Osborne, 2005). Table (4.39) stipulates that three of the extracted factors in the first run involved less than three item which were:

- The fifth factor involved only one item (activity), which was *SEM3* with factor loading equal to 0.55.
- The sixth factor involved only one item (activity) which was *SEM8* with factor loading equal to 0.54 .
- The seventh factor involved only one item (activity) which was *SEM11* with factor loading equal to 0.51.

Henson and Roberts (2006) reported that a factor with lower number of variables is weaker than factor with more items. However, these three factors can be removed by omitting the item included in each one of these factors alone. Accordingly, the three factors ( fifth, sixth and seventh) that involved these variables ( *SEM3, SEM8 and SEM11*) had to be dropped one by one and rotated component matrix shoukd be checked in each repetition. Note that, when more than one item to be removed, the priority for removal based on the value of the factor loading for each item so that, the item with the lowest factor loading should be removed first. Hence, in this data, the item SEM11 was removed first because it had the smallest factor loading when compared with the other two items *SEM3, SEM8*.

**<u>Third condition:</u> The item loaded on more than one factor with factor loading greater than 0.5 should be removed "no cross-loading items".**

By investigating the items in Table (4.37), it shows that three items were cross-loaded because each one of these three items was loaded on more than one factor by factor loading greater than 0.5, as follows:

- Item *SEM3* was loaded on the third and the fifth factors by factor loadings equal to 0.61 and 0.55, respectively.
- Item *SEM8* was loaded on the third and sixth factors by factor loadings equal to 0.6 and 0.54, respectively.
- Item *SEM11* was loaded on the second and the seventh factors by factor loadings equal to 0.66 and 0.51, respectively.

De Vaus (2002) concluded that, cross-loading item become a candidate for deletion from the analysis. On the basis of such results , the items *SEM3, SEM8 and SEM11* were deemed fit for elimination. So that , any cross-loaded item can be avoided in further analysis.

In summary, one item of these three items should be removed first to rerun the factor analysis run in the second repetition. So that, the item *SEM11* was removed first in this phase because it was loaded alone on the seventh factor with the lowest loading value (equals to 0.51) when compared with the other two factors deemed fit for removal. In addition, the percent of variance explained by the seventh factor (3.84%) was the lowest when compared with percent explained by the other two factors deemed fit for removal " fifth factor (4.03%) and sixth factor with factor loading equal to (3.86%), as shown by Table (4.36). Therefore, the item *SEM11* should be dropped first from analysis in the second run and all mentioned tests should performed on the data obtained from the following runs. Additionally, the extracted factors were then examined for the remaining data adequacy and strength requirements as mentioned in the previous discussion.

Table (4.37): Rotated component matrix for the first run for energy saving activities

| Item | Component | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| SEM15 | 0.86 | | | | | | |
| SEM20 | 0.85 | | | | | | |
| SEM16 | 0.83 | | | | | | |
| SEM18 | 0.82 | | | | | | |
| SEM19 | 0.79 | | | | | | |
| SEM4 | 0.75 | | | | | | |
| SEM10 | 0.75 | | | | | | |
| SEM33 | 0.70 | | | | | | |
| SEM31 | | 0.87 | | | | | |
| SEM30 | | 0.86 | | | | | |
| SEM25 | | 0.84 | | | | | |
| SEM7 | | 0.80 | | | | | |
| SEM5 | | 0.79 | | | | | |
| SEM13 | | 0.74 | | | | | |
| SEM11 | | 0.66 | | | | | 0.51 |
| SEM32 | | 0.56 | | | | | |
| SEM26 | | | 0.77 | | | | |
| SEM12 | | | 0.76 | | | | |
| SEM2 | | | 0.75 | | | | |
| SEM1 | | | 0.72 | | | | |
| SEM6 | | | 0.71 | | | | |
| SEM9 | | | 0.69 | | | | |
| SEM17 | | | 0.63 | | | | |
| SEM3 | | | 0.61 | | 0.55 | | |
| SEM8 | | | 0.60 | | | 0.54 | |
| SEM14 | | | 0.56 | | | | |
| SEM23 | | | | 0.81 | | | |
| SEM24 | | | | 0.80 | | | |
| SEM22 | | | | 0.79 | | | |
| SEM29 | | | | 0.75 | | | |
| SEM28 | | | | 0.75 | | | |
| SEM21 | | | | 0.69 | | | |
| SEM27 | | | | 0.69 | | | |

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

Several repetitions have been performed till obtaining a final solution satisfied all factor analysis requirements. In general, seven runs were conducted on the 33 energy saving activities involved in this study questionnaire. In each run after the first run, one item (activity) was removed from analysis as it violated one or more of factor analysis requirements. Therefore, six items (activities) were removed for different reasons and 27 item remained in the final solution fulfilled all factor analysis requirements and conditions. The items (activities) removed from the main data and the reason for its removal can be shown in Table (4.38), as follows :

1- *SEM17* has been removed in the second run of factor analysis because its communality value equals to 0.44 and less than the acceptance level ( at least equal or more than 0.5).
2- *SEM11* has been removed in the third run because it was cross-loaded on two extracted factors (second and seventh factors) and it was alone involved in the seventh factor.
3- *SEM8* has been removed in the fourth run because it was loaded alone on factor and it was cross-loading item.
4- *SEM21* was removed in the fifth run because it was loaded alone on factor and it was cross-loading item.
5- *SEM14* was removed in the sixth run because it was loaded with another item only on one factor making this factor involved less three runs and deemed fit for removal. In addition this item was cross-loading item.
6- *SEM3* was removed in the seventh run it was loaded alone on factor and it was cross-loading item.

Finally, the seventh run of the delivered factor analysis was regarded as the acceptable final solution because the output resulted from this run have satisfied all factor analysis requirements as mentioned in previous sections. Therefore, the seventh run of factor analysis was deemed appropriate for discussion and interpretation about the best energy saving activities in local construction sector. The following section concluded the reasons for the satisfactory of the solution obtained in the seventh run.

In the final run, as shown in Table (4.34), the reduced data set of 27 variables (energy saving activities) resulted in a Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy of 0.72, which considered as satisfactory. Another mode for determining the appropriateness of factor analysis, the Bartlett test of sphericity, reached statistical significance with (Chi-square= 1209.36) and significance level of (p-value = 0.000) which was lower than 0.05. In addition, all other requirements of factor analysis were satisfied in the final solution as described here:

1. The correlation matrix of the remaining variables involved several correlation coefficients between 0.3-0.9 without any value larger than 0.9 as shown in Table (E.9) in Appendix E.
2. All values of the measure for sampling adequacy (MSA) have been larger than 0.5 as shown in the anti-image correlation matrix presented in Table (E.10) of appendix E.
3. Communalities of the remaining items displayed in Table (4.35) were larger than 0.5.

4. Commutative variance of the four factor extracted in the fourth (final) run was 62.91% which is larger than 50 % as required. Total variance explained table for the final run can be shown in Table (E.11) of Appendix E.
5. Table (E.12) in Appendix E displayed that each one of the four factors extracted in the fourth run had more than two items loaded on it with factor loading more than 0.5.

Overall, in line with the mentioned requirements and consideration in factor analysis, four factors have been extracted from the final run (seventh run) which explained about 62.91% of the data variance and involved 27 items (activities) only. Table (4.38) below summarizes the results and actions taken in every run of factor analysis for the activities for energy saving to get the final solution. The following discussion provides description and interpretation for each factor.

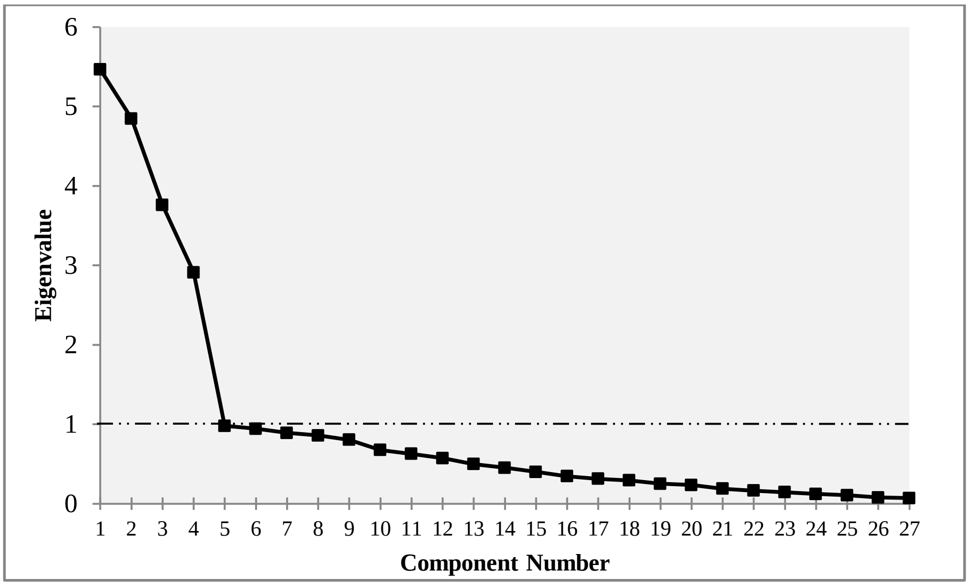


Figure (4.10): Scree plot of the final runs of best activities to save energy

**4. Reliability measure of the extracted factors.**

After extracting the final factors and identifying the variables loaded on each factor, it becomes important to check the reliability of each individual factor (component). To examine the appropriateness of the final four factors solution, reliability scores (Cronbach's Alpha, Cα) were calculated for individual factors included in the final solution. As shown in Table (4.39) Cronbach's Alpha (Cα) for these four factors ranged from 0.84 to 0.87, indicating adequate internal consistency. Additionally, Cronbach's Alpha (Cα) value for all the 27 items (activities) remaining in the final solution equals to 0.80. All values of Cronbach's Cα for all data and for each factor have been larger than 0.7, indicating adequate internal consistency according to Pallant (2005). Table (4.39) demonstrates the 28 remaining variables (activities) in four factors, and their respective factor loadings, explained variances, eigenvalues and Cornbach's α for each of the four factors. This table was prepared in the descending order with the topmost factor at the beginning and the items in each factor where arranged in descending order according to its importance based on its loading values in the factor contained it.

Table (4.38): Factor analysis runs and related data for best activities to save energy

| Requirement | Requirement threshold | Run number | | | |
|---|---|---|---|---|---|
| | | First | Second | Third | Fourth |
| Reliability of remaining variables | Cα > 0.7 | 0.82 | 0.82 | 0.81 | 0.81 |
| MSA values check for each variable | > 0.5 | Satisfied | Satisfied | Satisfied | Satisfied |
| KMO index | > 0.5 | 0.69 | 0.70 | 0.72 | 0.72 |
| Bartlett's test of sphericity "Sig" | < 0.05 | 0.00 | 0.00 | 0.00 | 0.00 |
| Communality values | > 0.5 | Satisfied except;<br>▪ SEM17 = 0.44 | Satisfied | Satisfied | Satisfied |
| Cumulative % of variance explained | > 50% | 69.88 % | 70.94% | 71.30% | 71.91% |
| No. of variables in each extracted factor | > 2 | Satisfied except;<br>▪ Factor no.5 (1 Item)<br>▪ Factor no.6 ( 1 Item)<br>▪ Factor no.7 (1 item) | Satisfied except;<br>Factor no.5 (1 Item)<br>Factor no.6 ( 1 Item)<br>Factor no.7 (1 item) | Satisfied except;<br>▪ Factor no.5 (2 Items)<br>▪ Factor no.6 ( 2 Items)<br>▪ Factor no.7 (0 item) | Satisfied except;<br>▪ Factor no.5 (2 Items)<br>▪ Factor no.6 ( 1 Item)<br>▪ Factor no.7 (0 item) |
| Factor loading of the variable | => 0.5 | Satisfied | Satisfied | Satisfied | Satisfied |
| Cross loading variable | => 0.5 on two factors or more | ▪ SEM3, SEM8 and SEM11. | ▪ SEM3, SEM8 and SEM11. | ▪ SEM3, SEM8, SEM14 and SEM21. | ▪ SEM3, SEM14 and SEM21. |
| Action taken for the next run "Removed item" | | SEM17 "communality value < 0.5" | SEM11 Cross loading on Factor no.2 & Factor no.7" "Loaded alone on Factor no.7" | SEM8 Cross loading on Factor no.3 & Factor no.6" "Loaded with another variable only on Factor no.6" | SEM21 "Cross loading on Factor no.3 & Factor no.6" "Loaded alone on Factor No.6" |

Table (4.38): Factor analysis runs and related data for best activities to save energy "Continued"

| Requirement | Requirement threshold | Run number | | |
|---|---|---|---|---|
| | | Fifth | Sixth | Seventh |
| Reliability of remaining variables | Cα > 0.7 | 0.81 | 0.80 | 0.80 |
| MSA values check for each variable | > 0.5 | Satisfied | Satisfied | Satisfied |
| KMO index | > 0.5 | 0.72 | 0.71 | 0.72 |
| Bartlett's test of sphericity "Sig" | < 0.05 | 0.00 | 0.00 | 0.00 |
| Communality values | > 0.5 | Satisfied | Satisfied | Satisfied |
| Cumulative % of variance explained | > 50% | 69.01% | 69.67% | 62.91% |
| No. of variables in each extracted factor | > 2 | Satisfied except;<br>▪ Factor no.5 (2 Items)<br>▪ Factor no.6 ( 0 Item) | Satisfied except<br>▪ Factor no.5 (1 Item) | Satisfied |
| Factor loading of the variable | => 0.5 | Satisfied | Satisfied | Satisfied |
| Cross loading variable | => 0.5 on two factors or more | ▪ SEM3 & SEM14 | ▪ SEM3 | No cross loading items |
| Action taken for the next run "Removed item" | | SEM14 Cross loading on Factor no.3 & Factor no.5" "Loaded with another variable only on Factor no.5" | SEM3 "Cross loading on Factor no.4 & Factor no.5" "Loaded alone on Factor no.5" | Final solution (All requirements were satisfied) |

- Extraction method : Principal components analysis (PCA).
- MSA: Measure of sampling adequacy for each variable.
- No. of extracted factors : Factors with eigenvalue larger than 1.
- Rotation method : Orthogonal Varimax rotation.
- KMO: Kaiser-Meyer-Olkin measure of sampling adequacy.
- Cross loading variable: Variable that loaded at 0.50 or higher on two or more factors

Table (4.39): Final results of factor analysis for best activities to save energy

| Code | Variable description | Factor loading | Eigenvalue | % variance explained | Cornbach's α |
|---|---|---|---|---|---|
| **Factor no.1 : Information and Communication** | | | | | |
| SEM15 | Collect information on available energy saving systems, technologies and policies in local construction sector. | 0.85 | 5.47 | 19.13 | 0.87 |
| SEM20 | Conducting periodic meetings and training programs for the contractors staff in energy conservation systems/technologies. | 0.84 | | | |
| SEM18 | Detailed reporting of the company onsite energy activities. | 0.84 | | | |
| SEM16 | Establishing good onsite communications between project staff about energy matters during construction phase. | 0.83 | | | |
| SEM19 | Use of a monitoring system for energy use during onsite works. | 0.79 | | | |
| SEM4 | Motivate the company employees to apply more onsite energy saving practices. | 0.75 | | | |
| SEM10 | Development of adequate energy database for the company projects. | 0.74 | | | |
| SEM33 | Using onsite energy manual (detailed work instructions) to save energy during onsite construction. | 0.72 | | | |
| **Factor no.2: Techniques and Technology** | | | | | |
| SEM31 | Utilization of renewable energies and green technologies for onsite production, transport and performance. | 0.86 | 4.85 | 16.79 | 0.84 |
| SEM25 | Replacement of onsite mechanical equipment with the use of manual labor where applicable. | 0.85 | | | |
| SEM30 | Using available energy saving technologies and solutions during onsite construction. | 0.84 | | | |
| SEM7 | Selecting subcontractors who are experienced in energy issues and management in construction . | 0.81 | | | |
| SEM5 | Adoption of more energy efficient construction methods as opposed to traditional construction methods during construction phase. | 0.79 | | | |
| SEM13 | Optimization of the transportation of raw materials and equipment to and within the site. | 0.76 | | | |
| SEM32 | Software development for onsite energy monitoring and evaluation. | 0.59 | | | |

Table (4.39): Final results of factor analysis for best activities to save energy "Continued"

| Code | Variable description | Factor loading | Eigenvalue | % variance explained | Cornbach's α |
|---|---|---|---|---|---|
| **Factor no.3: Equipment and Materials** | | | | | |
| SEM23 | Reducing the unnecessary use of energy consuming equipment and machines used during onsite construction. | 0.83 | | | |
| SEM24 | Replacement of high energy consuming equipment with lower energy consuming equipment. | 0.80 | | | |
| SEM29 | Reducing excessive material and wastage during onsite construction. | 0.80 | 3.76 | 14.05 | 0.86 |
| SEM22 | Frequent examination of the energy efficiency of all equipment used on construction site. | 0.75 | | | |
| SEM28 | Increasing the use of recycled building materials. | 0.75 | | | |
| SEM27 | Selecting where possible only local sources of materials supply. | 0.70 | | | |
| **Factor no.4 : Regulation and Management** | | | | | |
| SEM1 | Applying the governmental regulations requirements related to construction energy use. | 0.80 | | | |
| SEM12 | Systematic review and analysis for the energy consumption of onsite activities and equipment. | 0.76 | | | |
| SEM26 | Practicing of onsite construction methods leading to lower material use . | 0.76 | | | |
| SEM2 | Adopting of the governmental fiscal measures related to onsite construction energy issues. | 0.74 | 2.91 | 12.95 | 0.85 |
| SEM9 | Developing scientific, reasonable energy action plan for the project to make full use of onsite energy and resources. | 0.73 | | | |
| SEM6 | Participating in environmental friendly projects as possible. | 0.71 | | | |

*Kaiser-Meyer-Olkin measure of sampling adequacy = 0.73* *Total variance explained (%) = 62.91 %*
*Bartlett's test of sphericity: x2= 1310.24, df=251, p-value =0.00* *Total reliability Cornbach's α = 0.80*

***Third phase of factor analysis for energy saving activities: Factors naming and interpretation.***

Four factors were generated from the remaining 27 items (activities) on the basis of eigenvalue to be larger than 1. Hence, we can assume that the best activities for energy saving in local construction projects can be underlined with four groups or factors. These four factors were found to be significant enough to be used for further discussion and interpretation about the best activities to save energy in local construction projects. Because

PCA only groups strongly correlated variables together, possible names for each component can be proposed on the basis of the understanding of the content or relationship among the variables. The four factors extracted here were appraised to identify the underlying features that the loaded items have in common. This was done by looking for patterns of similarity between items that load on a factor. In addition, looking at what items do not load on a factor, to determine what that factor is not (Field, 2005). These factors have been labeled (named) after identifying the items involved in each one of these items with the general statistics related to each item such as factor loading and communality. In addition, the classification for sustainable practices proposed by Tan et al. (2011) helped in naming the extracted factors in this study who classified sustainable construction practices into five major areas: compliance with sustainability legislation, design and procurement; technology and innovation; organizational structure and process; education and training; and measurement and reporting. Zabihi et al. (2012) argued that sustainability aspects in the building are categorized in four groups of environmental, social, economic and technical issues. However, this research direction has greatly inspired the process of naming each component.

The cumulative total variance that was explained by the four factors solution accounts for 62.91% of the total variance in data. The factors generated here to represent the beast activities to save energy in local construction projects have been named as follows:

- **Factor no.1**: ***Information and Communication***; comprised of 8 items and has 5.47 eigenvalue which accounts for 19.13% of the total variance .
- **Factor no.2: *Techniques and Technology***; comprised of 7 items and has 4.85 eigenvalue which accounts for 16.79% of the total variance
- **Factor no.3: *Equipment and Materials***; comprised of 6 items and has 3.76 eigenvalue which accounts for 14.05% of the total variance
- **Factor no.4: *Regulation and Management***; comprised of 6 items and has 2.91 eigenvalue which accounts for 12.95% of the total variance

Experts involved in earlier phases of this research have been consulted to help research in naming the factors extracted from the used energy saving activities. Hence, they provided a valuable suggestion in naming and validating the labels suggested for these factor. Figure (4.11) illustrates the proposed designation for the components. These results illustrate that the dominant number of energy saving activities in local construction projects can be interpreted by four main groups. The following sections will interpret and discuss each of these component

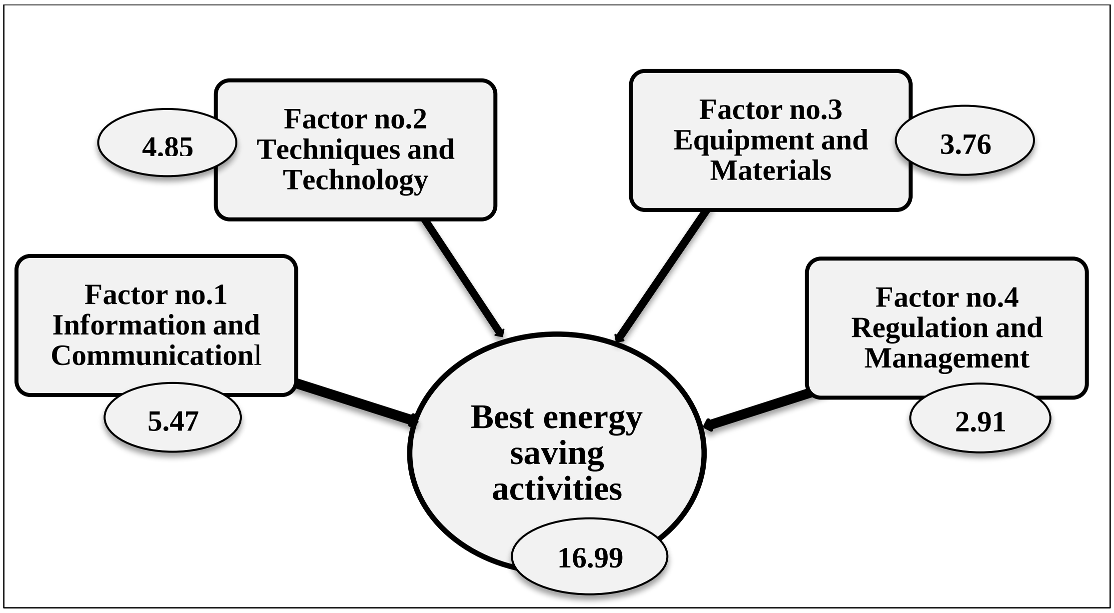


Figure (4.11): Final factors extracted from factor analysis on best activities to save energy

- **Interpretation of the principal factors for the barriers to adopt energy management in local construction contractors.**

The resulted obtained from the previous processes have been interpreted here and wider discussion on each factor has been presented. In the following sections, general discussion about the four factors extracted from factor analysis has been prepared. In addition, the contents of each factor have been assessed and verified, as follows;

***a) Factor no.1 : Information and Communication***

This factor is the first factor extracted in such a way that it explains the largest portion of variance. So that, it can be considered as the most effective factor from the extracted factors as it accounts for 19.13% of the total variance and comprises 8 items with relatively suitable large factor loadings (>0.50). The nature of the items involved in this factor and there factor loading justifies naming it as "*Information and Communication"* because the contained items addressing issues related to information and knowledge sharing aspects in local construction sector. It is clearly evident that information and communication issue are the need of the hour. Due to advancement in technologies and developed techniques in the dynamically changing world, knowledge about the new technologies and practices being introduced also of prime importance. Information and communication programs provide industries with information on energy efficiency technologies and practices that may be difficult, costly, or time-consuming for individual enterprises to gather (Price and Worrell, 2000). Plessis (2002) contended that, accurate data and information is critical to achieving effective sustainable construction processes and policies. As a general role, without information and communication on the collection, analysis and use data pertaining to energy consumption in constructions, top management will not be able to make any decision to use energy efficient techniques. WBCSD (2008) reported that information and education are key elements to change knowledge into action. In the same line, Choong et al. (2012) described that, communication, awareness, education, and training about energy management are essential to foster positive attitudes, educate knowledge, and develop necessary energy-management-related skills among employees. UNIDO (2007) indicated that, information campaign can be considered as a core element of any industrial energy efficiency program as it can introduce industry to the basic concepts of energy management and industrial system optimization. To save more energy and adopt efficient energy practices in construction UNCHS (1991) stated that, all contractors will want to know over all information about available techniques for application now, and what techniques are currently under development or might become available in the near future However, internal communication in the industrial organizations with regard to its energy performance and the energy management system will ensure that all persons working in this organization can take an active part in the energy management and the improvement of the energy performance (ISO, 2008).

Training the contracting organizations staff in the specific field of energy saving enhances the ability of the companies to practice energy saving activities (Liu et al., 2012). In addition, training programs can increase staff awareness and motivation so that they can participate in generating suggestions for efficient energy use (Vesma, 2012). Periodic meeting is one of the most important information programs to assure stakeholders understands the energy management task and agrees on the proposed approaches in solving identified energy problems (Wai et al. 2011). In addition, the creation of documentation like an energy manual is an effective means of communicating and educating working personnel of the energy program (Apeaning, 2012). According to the previous discussion, since energy management and saving issues is a fairly new concept in the Palestinian construction industry, it is important to provide a valuable information and awareness development programs an communicate the energy use goals and objectives to all construction in order to achieve efficient energy use and successful energy management program execution. The first location and the higher importance of the information and communication activities for energy saving is attributable primarily to the local contractors lack of energy management know-how and information.

Correlation coefficients between the items forming the first factor have been determined and tabulated in correlation matrix of Table (4.40). Determining the correlation between these items can be considered as an important technique to validate the results obtained from factor analysis . In addition, by investigating the values in this table, core concept factor analysis in factor extraction can be verified. Therefore, the correlation coefficients between the 8 items (activities) forming the first factor of this study shown in Table (4.40). It is clear that these items correlated by correlation factor ranged from 0.34 to 0.79. These correlations can be considered significantly strong because there values more than 0.3 as assumed by De Vaus (2002). Therefore, collecting these eight activities (items) under one heading can be considered suitable and acceptable as obtained from factor analysis. Looking at these activities , there nature related to on aspect that is awareness, knowledge enhancement activities to save energy during project construction. In addition, the extracted factor alone can playing an important role identical to the roles of the eight activities comprised this factor in saving energy in local construction projects..

Table (4.40): Pearson correlations between the items "activities" in *"Information and Communication"* factor

| Item | SEM4 | SEM10 | SEM15 | SEM16 | SEM18 | SEM19 | SEM20 | SEM33 |
|---|---|---|---|---|---|---|---|---|
| SEM4 | 1.00 | | | | | | | |
| SEM10 | 0.39** | 1.00 | | | | | | |
| SEM15 | 0.76** | 0.58** | 1.00 | | | | | |
| SEM16 | 0.60** | 0.59** | 0.58** | 1.00 | | | | |
| SEM18 | 0.54** | 0.55** | 0.64** | 0.65** | 1.00 | | | |
| SEM19 | 0.54** | 0.59** | 0.73** | 0.50** | 0.67** | 1.00 | | |
| SEM20 | 0.56** | 0.79** | 0.65** | 0.79** | 0.59** | 0.55** | 1.00 | |
| SEM33 | 0.41** | 0.34** | 0.50** | 0.56** | 0.70** | 0.53** | 0.44** | 1.00 |

***. Correlation is significant at the 0.01 level (2-tailed).*

### b) ***Factor no.2 : Techniques and Technology***

The second group of the best activities for energy saving is related to the technical view and available technologies to be used in energy saving. Therefore, this factor was named *"Techniques and Technology"*, which accounts for 16.79% of the total variance and comprises 7 items (activities). In fact, greening of construction projects requires the development and implementation of new technologies aimed at reducing the negative impact of the sector on the environment, and enhanced performance of infrastructure (Wyk et al., 2011). Ates and Durakbasa (2012) demonstrated that energy management considered in many organizations as a matter of technical settings, although the management and organizational side are also essential aspects. It is well known that a lot of energy efficiency improving measures could be realized from a technical point of view and that they would be economically profitable (Weber, 1997). UNEP (2006) observed that, company management in developing countries often considers new technologies as the only way to significantly improve resource efficiency. In the same line, Chuanzhong and Yingji (2011) asserted that, technology innovation is the fundamental guarantee of energy efficiency. Based on energy saving technologies results in the industrial sectors, it has been found that a sizeable amount of energy, emissions and utility bill can be saved using these technologies (Abdelaziz et al., 2011). However, Jiang (2008) indicated that, by technological innovation, energy efficiency and develop can be continued in order to realize long term energy development that sustains modernization.

There are many techniques and technologies provided to save energy. Renewable energy sources and green energy technologies are now the pathways in achieving sustainable "green energy" development and highly in increasing energy efficiency (Mohanty, 2012). Renewables are often cost competitive with fossil fuels in countries without fossil fuel subsidies in place (UN Global Compact and Accenture, 2012). The main renewable energy sources applicable to Gaza Strip are solar and wind energy. Solar energy is abundant in Gaza Strip with a considerable amount provided as a result of its location near the hot dry region of the world (Muhaisen and Ahlbäck, 2012). However, the use of renewable energy in

Palestine, especially solar power, is very low in comparison to available capacities (MoPAD, 2009). On other hand, computer software is one of the most useful ways and techniques for maintaining the operation of the whole energy system under investigation and for solving problems related to energy conservation and management (Al-Mofleh et al., 2009. The limitation of the scope and applicability of new technologies or techniques may force industry practitioners to move back to traditional construction methods (Shi et al., 2013)

Second factor named *"Techniques and Technology"* generated as a result of the relationship between the seven variables (activities) comprises this factor. The correlation matrix of these variables has been produced and scanned to certify the results obtained from the factor analysis that performed for the 33 listed activities for energy saving. From Table (4.41) below, the correlation coefficient between each pair of the seven variables ranged between 0.42 and 0.72. according to De Vaus (2002) assumption, the strength of the relationship between each pair of these seven variables can considered relatively strong because all values of the correlation coefficients (r) are larger than 0.3. For example, the variable\item *SEM13* correlated with each one of the other six variables by a correlation coefficient larger than 0.3 to form the first factor with a correlation coefficients (r) equal to 0.53, 0.57, 0.56, 0.50, 0.58, 0.59 and 0.46 with the items *SEM5*, *SEM7*, *SEM25*, *SEM30*, *SEM31 and SEM32*, respectively. On the basis of the mentioned results, the factor analysis solution for the second factor can be considered confident and suitable for interpretation and covering the variables involved.

Table (4.41): Pearson correlations between the items "activities" in "*Techniques and Technology"* factor

| Item | SEM5 | SEM7 | SEM13 | SEM25 | SEM30 | SEM31 | SEM32 |
|---|---|---|---|---|---|---|---|
| SEM5 | 1.00 | | | | | | |
| SEM7 | 0.50** | 1.00 | | | | | |
| SEM13 | 0.53** | 0.57** | 1.00 | | | | |
| SEM25 | 0.77** | 0.59** | 0.56** | 1.00 | | | |
| SEM30 | 0.62** | 0.64** | 0.50** | 0.75** | 1.00 | | |
| SEM31 | 0.58** | 0.74** | 0.58** | 0.67** | 0.79 | 1.00 | |
| SEM32 | 0.44** | 0.40** | 0.46** | 0.43** | 0.40** | 0.38** | 1.00 |

***. Correlation is significant at the 0.01 level (2-tailed).*

### c) ***Factor no.3 : Equipment and Materials***

Third factor explains 14.05% of the total variance and represented by six variables (activities). These six activities have a factor loading larger than 0.5. This factor involves a number of activities related to the best use of the project materials and equipment to save energy more during construction. It also involves equipment changes to reduce energy consumption and could include improved onsite equipment, newer more energy efficient equipment and materials, etc. So that , this factor was named as "*Equipment and Materials"*. Eventually, energy performance of an organization is influenced by the equipment and materials as it consume the highest amount of energy during project construction. Therefore, best practice requires that energy performance of such items is taken into account during execution (Carbon Trust, 2011). The adverse impacts of construction activities and products on the physical environment would only be effectively minimized through efficient use of project resources including equipments and material (Plessis, 2002). Davies et al. (2013a) argued that, efficient use of materials and equipment during on-site construction can provide savings in fuel use, cost and improve site safety. Kahlenborn et al. (2010) recommended industrial companies to make equipment and materials energy efficiency as criterion for evaluation in the company procurement processes. In the same line, Shi et al. (2013) argued that the use of green materials and equipment are vital factor for the implementation of sustainable construction practices. In fact, the misapplication of energy-efficient equipment in industrial systems is common. The disappointing results from these misapplications can provide a serious disincentive for any subsequent effort to achieve greater energy efficiency (UNIDO, 2007). However, the limited availability of energy efficient materials and equipment in the local market is a significant challenge facing the construction industry. Several methods for minimizing material and energy wastage during building construction process and providing opportunities for recycling and reuse of building material also contribute to improving resource consumption efficiency (Akadiri et al., 2012). The recycling and reuse of construction materials is one component of energy efficiency in sustainable construction (UN Global Compact and Accenture, 2012).

The previous sections have revealed that recycling is a possible and desirable way of reducing energy consumption in the manufacture of most building materials (UNCHS, 1991). Proper maintenance of equipment increases its expected life, improving performance and reducing energy use (Fisher and Bristow, 2009). Wai et al. (2011) recommended to perform regular proactive and reactive maintenance on energy relevant equipment to sustain energy consumption. Performing routine maintenance on equipment can help identify leaks and other problems that would impede performance and reduce efficiency.

Table (4.42) below presents the correlation matrix between the items forming the second factor. From this table, it is clear that the four items inter-correlated with a correlation coefficient ranged from 0.36 to 0.71. This result indicated that these items significantly correlated together by relatively strong degree ($r > 0.3$), besides that, the correlations between them are positive which mean that increase in one item will cause increase in other items. The correlation analysis implies that these six items and its grouping factor determine the role of the efficient management of the equipment and materials in saving energy use in construction. So that, the significant associations between these items strengthened the findings presented in factor analysis which clustered all of these six activities under one factor.

Table (4.42): Pearson correlations between the items "activities" in "Equipment and Materials" factor

| Item | SEM22 | SEM23 | SEM24 | SEM27 | SEM28 | SEM29 |
|---|---|---|---|---|---|---|
| SEM22 | 1 | | | | | |
| SEM23 | 0.52** | 1 | | | | |
| SEM24 | 0.63** | 0.71** | 1 | | | |
| SEM27 | 0.42** | 0.50** | 0.48** | 1 | | |
| SEM28 | 0.59** | 0.58** | 0.47** | 0.36** | 1 | |
| SEM29 | 0.40** | 0.59** | 0.47** | 0.58** | 0.60** | 1 |

***. Correlation is significant at the 0.01 level (2-tailed).*

### d) ***Factor no.4: Regulation and Management***

The fourth factor was labelled *"Regulation and Management"* involved six items and accounts about 12.95% of the total variance in data. It is shown that these six items appear with acceptable large loadings (> 0.50) on this factor. In general, this factor including items addressing aspects related to regulation and managerial systems in industry. Although its importance this factor has the least variance explained which mean that it is the least significant factor from the extracted factors for energy saving in construction. Combining managerial activities with regulation may be justifiable as governmental measures to increase energy efficiency can only be taken and implemented sustainably if management recognizes and supports energy management. Wai et al. (2011) indicated that, the best way to insure that energy management activities are applied through compliance with statute, regulation and contractual requirements. Djokoto et al. (2014) stated that, the fragmented nature of the construction sector and the high number of actors involved may lead to a situation where regulations are considered as the only possible way to proceed.

The respondents are well aware about the needs to comply with energy legislation although the local regulations lack any lows related to energy management in construction sector. A study conucted by Khalfan et al. (2015) revealed that, many contractors in Australia perceived that by complying with the legislation can offer significant reductions in costs while at the same time significantly improving the negative effects on the environment and comfort of any facility. Shi et al. (2013) noted that, governments worldwide have introduced various policies and regulations to mitigate the significant impacts of construction activities on society and environment. In reality, several countries have developed energy management standards and practices as an effective industrial energy efficiency policy mechanism (UNIDO, 2007). In addition to its role as regulator, there is strong support for the government to take a leadership role in the delivery of sustainable construction by using its powers as a major customer and industry sponsor and also to establish a national vision for sustainable construction (Majdalani et al., 2006). So that, Kahlenborn et al. (2010) recommended industrial companies to regularly assess to what extent the legal obligations of the company have been complied with the governmental regulations related to energy management.

In order to validate the factor analysis results, correlational analysis was undertaken to show the relationship between the six items included in the fourth factor. An evaluation of the linear relationship between the six items included in the this factor was measured using Pearson's correlation. Table (4.43) below, indicated that there is significantly strong linear relationship between the six activities which formed "*Regulation and Management*" factor. Because these correlation values are greater than 0.3. Therefore, factor analysis for this factor can be considered satisfactory.

Table (4.43): Pearson correlations between the items "activities" in "Regulation and Management" factor

| Item | SEM1 | SEM2 | SEM6 | SEM9 | SEM12 | SEM26 |
|---|---|---|---|---|---|---|
| SEM1 | 1.00 | | | | | |
| SEM2 | 0.52** | | | | | |
| SEM6 | 0.37** | 0.52** | 1.00 | | | |
| SEM9 | 0.57** | 0.39** | 0.42** | 1.00 | | |
| SEM12 | 0.45** | 0.46** | 0.44** | 0.43** | 1.00 | |
| SEM26 | 0.49** | 0.47** | 0.48** | 0.52** | 0.68** | 1.00 |

*** Correlation is significant at the 0.01 level (2-tailed).*

Chapter 5

# Conclusion and Recommendations

This section concludes the research study and provides details and various findings in relation to the research objectives. Two main parts forming this chapter, first part summarizes research method used to fulfill the study objectives and it provides a brief about the findings and impacts of this study. Second part provides a valuable recommendations for best practices to be performed from several parties in Palestine to broaden energy management understanding and application. In addition, recommendations for further researches are provided.

## 5.1 Research summary

Energy problems tend to happen in local construction sector mainly due to inefficient use of energy and lack of skills among construction industry participants. This study has attempted to perform an overall evaluation of how far local contracting organizations have reached with respect to energy management during project construction. The study has also determined what these firms consider the most important drivers and barriers to further adoption of energy management, and suggested activities for how energy use can be reduced during project construction. From an extensive review of the literature in the field of energy management, sustainable construction, green construction and energy efficiency in addition to the experts revision and suggestions about the collected data, 10 features were identified to measure contractors awareness, 17 requirements to identify the application level, 26 drivers were finalized and 31 barriers were provided for energy management adoption in local contracting organizations and 33 energy saving activities were proposed to attain less energy use and reduce environmental impacts from construction activities. Data used for analysis are collected from a comprehensive questionnaires filled by 76 project managers and site engineers working in local contracting organization. These data was then organized and analyzed using SPSS software version 22. To satisfy this study objectives, two stages of data analysis were processed. The first stage consisted of some techniques of descriptive and inferential statistics involving mainly, Mean Score (MS) and Relative Importance Index (RII) to put the study statement\variables in order format. Exploratory factor analysis was then used for data reduction to establish clustering systems for the statements\variables involved in study. The findings are then investigated and interpreted to provide recommendations for improving the overall development of energy management practices for construction industry in Gaza Strip.

## 5.2 Research Outcomes

Changing how energy is managed by implementing an organization wide energy management program is one of the most successful and cost effective ways to bring about energy efficiency improvements. This study aimed to create an understanding of how energy issues are managed during construction process in construction contracting firms working in Gaza Strip. In order to achieve this aim, four objectives are provided and executed, the main findings of the research are in the following, divided by research objectives.

### 5.2.1 First objective outcomes

This objective established to assess the local contractors level of awareness about energy issues and energy management in construction industry. Several features related to sustainability and energy issues are used to determine contractors level of awareness about energy management. The findings about this objective can be arranged in the following points:

- The major observation that can be drawn is that the local construction contractors in Gaza Strip have a moderate degree of awareness about energy management.

- Local contractors aware that there is a huge gap concerning efficient energy use in construction as a result of the shortage in skills and knowledge relevant to efficient energy use technologies.

- The majority of the respondents have agreed about awareness statements that cover economic and environmental aspects of energy management.

- Economic benefits related to energy management were known to the local contractors more than the environmental related issues.

- The majority of energy management strategies in construction have positive financial implications to the contractors, which may explain the high level of awareness and positive attitudes towards this subject.

- Improvement in competitive advantage gained as a result of applying energy management has a far greater focus amongst the local contractors than the other energy management benefits.

- Local construction contractors know that energy use in construction negatively affect the surrounded environment. Otherwise, the provided statistics pinpointed that there is a lack of understanding of the nature and forms of these negative environmental impacts such as GHG emissions. This results can be attributed to new worldwide wide concerns about the environmental impacts of energy use in construction.

### 5.2.2 Second objective outcomes

The second objective of this study was issued to identify the degree of practice of energy saving and management during construction process in local contracting firms. Systematic examination was conducted of the local contracting organizations by using the 17 energy management requirements proposed through study, which reflected the application level of energy management in contractors construction activities. The study findings related to this issue can be concluded as follows:

- Contracting companies in Gaza Strip were not strictly applying energy management in their projects as many of these companies have not considered energy issues seriously. They didn’t put energy issues on top list during construction activities.

- The study found that although the sampled firms were not at ground zero with respect to energy management practice, their overall performance in energy efficiency and management was relatively poor.
- This poor application level emerged because local contractors lack of specified knowledge about techniques and strategies for energy management .
- Some issues related to energy management concept applied locally on a small scale with informal system, nonprofessional approach and without well-structured framework. as a result of the contractual requirements. So that, contractors hadn't attained full return from this form of practice.
- This application fashion of energy management can be used to interpret the existence of an energy management gap between awareness and application levels in local construction sector. Energy management gap generated because this study demonstrated that, whilst there seems to be a reasonable level of awareness amongst the contracting companies about the benefits of energy management, this awareness is not currently well reflected in the construction practices actually being applied.
- Environmental management program for each project was the major requirement applied in local construction industry. Although its moderate application level, local contracting companies prepared environmental management programs as a result of the contractual requirements only, because large projects in Gaza Strip financed by international organizations or from developed countries who has abroad concern of environmental issues.
- Requirements specified for environmental programs preparation in local construction sector didn't specifically related to energy issues and impacts but it often related to other environmental impacts related to the construction activities such as dust and exhaust, etc.
- Existence of some barriers or absence of several motivates to save energy in construction sector are the main reasons for energy management gap in local construction sector. So that, separated part of this study was performed to explain reasons for this limited practice level "fourth objective" and another part was conducted to help in increasing this application level " third objective".
- Results indicated that there is strong relationship between awareness and application of energy management. The gap appeared in this study resulted from many barriers inhibiting the adoption of energy management strategies. Awareness of local contractors related to the benefits and impacts of energy management application whereas they aren't aware about the techniques and technologies to practice successful energy management program.

### 5.2.3 Third objective outcomes

This objective established to explore the major drivers enhancing local contractors to adopt energy management during project construction. Several common driving forces were used to indicate the most effective drivers to implement energy management strategies in local contracting firms during project construction.  Findings related to this objective include the following:

- Local construction contractors can be subjected to several types of driving forces that may promote them to adopt energy management and energy saving technologies during project construction.
- The most effective driving forces for local construction contractors to adopt energy management  in construction projects that ranked at the first three position from overall data, were:
    1) *Cost saving gained from adopted energy management strategies.*
    2) *Existence of government regulations related to energy consumption and saving issues for construction industry.*
    3) *Strength and enforcement of the governmental requirements for onsite construction energy saving.*
- The level of uptake and investment in adopting energy management in construction would be accelerated if evidence for the financial benefits for energy management were proven.
- Assuming the existence of governmental regulations concerning sustainability and energy issues in Palestine, the respondents considered complying with these regulations as one of the best ways to drive the implementation of energy management in local construction companies.
- Although the importance of scientific researches in driving energy management adoption. There is no effective governmental funding mechanisms and support in Palestine to encourage researchers to perform different researches especially which are related to sustainable construction and energy improvement researches. This can explain the respondent perception about the least importance of scientific research in driving sustainable energy management in Palestinian context.

In addition, factor analysis on the initial data of the 26 driving forces for energy management was performed and several runs of factor analysis including many checks and test on these data. From the remaining 19 acceptable energy management adoption drivers have been grouped under four factors that can explain the major forces for energy management adopting in local construction sector which were :

1) ***Factor no.1:*** *Economic and Financial;*
2) ***Factor no.2:*** *Institutional and Legal;*
3) ***Factor no.3:*** *Organizational and Managerial;*
4) ***Factor no.4:*** *Education and Information.*

These factors arrangement indicates that majority of the contractors see that economic and financial related issues need to be discussed and actions to be taken to increase the application of energy management in local construction companies.

### 5.2.4 Fourth objective outcomes

This objective aimed to identify the key barriers to the implementation of energy management in local contracting companies during the project construction. This section has identified a series of problems that inhibit energy management application in construction. There are various barriers encountered in developing efficient energy use and management in local contracting companies during project construction, the top three barriers according to the ranking order were :

1) *Additional costs needed to improve the company energy efficiency;*
2) *Lack of the company staff awareness on the importance of energy management during onsite construction;*
3) *Company senior management doesn't provide support for energy saving activities.*

These barriers can be explained by the following concluded statements:

- It is clear that the most important barriers to further energy efficient use related to financial aspects which found to be consistent with overall results in this study.
- There is a belief between local contractors that energy management application will raise the cost of construction projects without a quantifying benefits; a perception that poses the most important challenge for energy management adoption in local contracting firms because local contractors concerned about any additional costs when considering the implementation of new norms or new technologies in their organizations.
- Several reasons caused low support for energy management from mangers and decision makers in local contracting firms as they focus more on production as the core activity in construction sites and energy efficiency doesn't taken into account.
- Progress on sustainability and energy management in local construction sector depends on people in the industry being aware of the importance of this issue, and then being able and willing to act on it. Lack of support from local contracting organizations management to their employees considered as one of the most significant reasons for impeding energy management practice in Gaza Strip.
- Local contractor onsite workers and staffs have a limited awareness of the cost and benefits of energy management practices, this low awareness level can be reflected in poor level of energy management application among the industries surveyed.
- There is a resistance among different staffs of the construction companies to change the conventional construction methods and processes to more energy efficient practices.

Four grouping factors emerged from the 28 suitable barriers remained in the final solution. These factors have been named as follows:

1) ***Factor no.1:*** *Economic and Financial.*
2) ***Factor no.2:*** *Knowledge and Information*
3) ***Factor no.3:*** *Legal and Contractual*
4) ***Factor no.4:*** *Organizational and Management.*

The most significant results obtained from these factors can be declared in summary as follows:

- Barriers generated from the financial and economic issues are the main reasons for impeding local contractors to adopt energy management during project construction.
- Most of the contracting firms in Gaza Strip lacked skilled personnel to evaluate the performance of an energy efficiency technologies. Lack of skilled and experienced persons in energy issue occurred because energy management in construction still relatively new in Gaza Strip.
- Existing contracting and tendering process in local construction sector have lots of drawbacks, focusing on low cost and less time and ignorance of performance, that affect the energy management movement negatively.
- Lack of the client/donor awareness of the importance of energy management during onsite construction results in perceiving energy efficiency improvement specifications and conditions as secondary when preparing the contract documents and when selecting the contractor to complete the project

### 5.2.5 Fifth objective outcomes

This objective considered as the most important objective of the present study as it was proposed to determine contractor best activities to reduce the energy use in construction projects and subsequently to prioritize them. The top three activities that can produce the highest reduction of energy use in construction , according to respondents were:

1) *Adoption of more energy efficient construction methods as opposed to traditional construction methods during construction phase.*
2) *Conducting energy audits on the construction site to identify energy use and energy saving opportunities.*
3) *Motivate the company employees to apply more onsite energy saving practices.*

Summarized significant notes for these activities can be reported as:

- Local contractors believed that new modern techniques and construction methods can provide highest return and energy saving in local construction projects and more than the traditional practices applied today. This results implied that changing construction methods may seem impressive and attractive and it is the favorite solution for energy conservation locally.

- This finding also illuminated that local construction contractors have realized the importance of energy audits in estimating typical energy costs for construction activities and equipment usage and to assess the level of progress of ongoing programs.
- Local contractors emphasized that, motivation of all levels and functions employees and the commitment shown for an energy management are of major importance for the long-term success of an energy management to save energy in project construction.
- One of the surprising results of this study is the local contractors vision about energy management code as not an essential element in saving energy and the successful practice of energy management in local construction. Many reasons can describe this exceptional view such as, codes in construction aspects don't help solving the cost problem related to energy management system adoption that mentioned in several of this study, local codes of practice in different aspects of construction are advisory rather than mandatory, specifications for energy saving in construction have not been established properly in Palestine because energy saving technologies is still at an early stage and code officials' in local construction sector knowledge about energy saving materials, processes, techniques etc. not sufficient to produce the required codes. So that, existence of energy management code in local construction sector will not help in saving energy unless these codes prepared by scientific methods and take high attention of the government and local construction organization.

Factor analysis aimed to group appropriately the remained valid 27 activities into few manageable factors which can explain major part of the data, the four factors have been labeled as follows:

1) ***Factor no.1:*** *Information and Communication*
2) ***Factor no.2:*** *Techniques and Technology*
3) ***Factor no.3:*** *Equipment and Materials*
4) ***Factor no.4:*** *Regulation and Management*

Information and communication issue represents the most need to develop energy saving during project construction. Information about new practices, technologies and developed techniques are required continuously. without information and communication on the collection, analysis and use data pertaining to energy consumption in constructions, top management will not be able to make any decision to use energy efficient techniques.

## 5.3 Theoretical and practical implication

The implications of this study findings for efficient energy construction in Palestine in the future are interesting. However , the following points describe the main applications of this study:

- In this study by review and studying definitions and concepts of energy management in construction, a comprehensive definition can be fulfilled.

- This study will allow contracting companies to understand where they fall within energy saving and sustainability issues and identify problem areas that should be improved to devise a strategy to be developed and to attain higher levels of sustainable energy management.
- This study provides a valuable references for studying the practice of energy management development in other industries and locations.
- The findings of this study can provide a reference for adopting effective practices in order to obtain the efficient energy use. Some guidelines have been proposed as an outcome of the survey to encourage efficient energy practices and to save energy during project construction.
- The priority of the methods, challenges and drivers for energy management will help the local contracting companies to focus on weak and strong points in the company for energy use development in order to remove these weak points and invest strong points.
- Efficient energy management activities proposed in this study can help construction organization development and performance as new energy activities and innovative energy technologies are key to operate successfully locally in the coming years.
- Justification of positive financial impact in energy management has been deemed necessary to gain greater acceptance and adoption of efficient energy practices in local construction sector.
- This study results can increase the social responsibility of the contracting organization toward energy use.
- Finally, further researchers may be able to use this study method and results to develop energy management program for construction sector.

## 5.4 Originality/value

This study contents, methods used and findings making it to be considered as one of the most significant studies about energy issues in local construction sector. The value of this study can be shown in the following points

- This study presents the first investigation into energy management aspects in local construction industry, especially from contracting organizations perspective.
- This study results will open the door for more discussion about all subjects related to energy use and saving in construction
- The results of this study can be of immense benefit to policy makers and construction industry practitioners (clients, contractors and consultants) and academicians.
- Other industries practitioners and researchers can benefit from this study findings because this study data collection and questionnaire was established on the basis of an extensive literature review of several researches from other industries than

construction industry. However, it should be noted that this instrument is more valid for construction companies than for companies in other industries.

## 5.5 Limitations:

The researcher appreciate the limitations in this study. The followings are the major limitations related to this research:

- This research findings refer to Gaza Strip context, though energy management and saving strategies and technologies are widely used in many other developing countries.
- The implementation of energy management and saving strategies should be achieved through various channels including government, construction officials and stakeholder. However, due to limited time, this research focuses on identifying the energy management strategies implemented by contracting firms only. It is conceivable that investigating other industry members such as clients and consultant might provide different results.
- To obtain more consistent results, this study focused on the first three classes of local contracting companies. Other classes should be included in further investigations.
- This study focused only on the perception of projects managers and site engineers who have extensive experience to attain a valuable suggestions and understandings from local construction sector.
- This study focused on the managerial side for the areas related to energy management development , specific technical side not studied widely.
- Non-availability of common data in Gaza Strip about energy management  are also deemed as the limitation to this research because the topic of energy management locally and in construction sector particularly has received no or very little attention so far. However, there are surprisingly few studies that have examined energy management in this large and important industry.
- Many definitions exist for energy management which causes some level of confusion and disagreement within the advisory documents, as well as amongst project stakeholders on what energy management means and how it could be implemented within construction project environments.
- The questionnaire is somewhat limited, for the sample size is small and it is the summary of opinions towards the importance of predetermined factors.

## 5.6 Future research

There are many possibilities for further research in this content because it is a new approach in construction industry. This study has thrown up many questions in need for further investigation. It is recommended that further research be undertaken in the following areas:

- The costing, quantitative gains, community benefits, and problems of energy management implementation need to be researched, probably through in-depth case studies or action research.
  - There is a need for much more in-depth financial analysis of the costs associated with energy management strictly from a contractor's perspective.
  - Further researches are needed to investigate the contents and applicability of international policies, strategies and regulations related to energy efficiency and management.
  - It is recommended to carry out further studies on the best methods to improve and strengthen the contractors staff knowledge and skills to develop energy adoption application .
  - Correct procedure for the application of energy management principles in construction should be investigated in future studies.
  - It is worthwhile to measure the current practices of energy management in Palestinians'' construction companies.
  - Comprehensive research shall be done for a project which includes all sectors of the construction industry. It is necessary to consider the whole life cycle and stakeholders of construction projects to be involved in further researches .
  - The results of this study suggested the need for shifting the traditional methods for constructing projects to modern energy efficient methods. So that, it will allow for future research focused on developing further and validating the best methods and technologies for energy management engagement in construction. Effectiveness of these activities and how it can be implemented should be studied.
  - More research on this topic needs to be undertaken on the recent and modern technology innovations and techniques for energy saving applied in developed countries.
  - Further comparative study can be conducted to verify whether the findings are applicable to other participants of construction industry.
  - Further research should be performed using larger sample of several experience especially low level employees.

## 5.7 Recommendations:

Although there is some awareness about the concept of energy management, Palestinian construction companies have little knowledge and experience on energy management standards and techniques. This problem brings the question that what should be done to create and develop energy management system of construction companies. Local construction sector is very conservative and not in favor of change, so that its organization has not changed from a long time. The following recommendations are provided to increase energy management adoption in local construction sector and to solve major problems faced during this study process.

- Improving the knowledge and level of awareness of energy management techniques, technologies and applications could make a large impact on the applications of sustainable energy management in construction. Therefore, there is a need to provide a more in-depth education and training for all construction industry stakeholders in general in relation to the fundamentals of sustainable energy techniques in construction. Skills development and training specifically for these new technologies must be developed rolled out.
- Current environmental and energy related regulations in all sectors are not available in Gaza Strip. It is therefore concluded that, there is a pressing need for intervention from government in order that the use of sustainable energy in construction strategies becomes the norm in Palestine.
- In addition, construction organizations need to devise appropriate measures to respond to governmental regulations related to any environmental subject. These measures include compliance with legal frameworks, technological innovation and managerial processes improvements.
- Government must set up incentives, measures and legislation to encourage the local industries to provide environment friendly materials.
- To encourage sustainable energy practices, government can provide some economic incentives for using local construction materials .
- Contractors should develop and maintain effective monitoring, reporting, and management to assist decision-making for wise energy usage
- Local contractors should provide extra incentive for their onsite workers to actively seek and apply more energy efficient practices.
- Contracting organization should appoint representative with the appropriate skills and training to be responsible about all energy issues and apply successful energy management program.
- Construction companies should make equipment and materials energy efficiency as criterion for evaluation in the company procurement processes.
- Contractor management requires awareness of the costs and benefits of energy management as they are the most influential stakeholder.
- Improvement of the construction process as opposed to the traditional methods involving cataloguing of best practice for energy saving and management and its roll-out to the sector is required.
- More educated employees should be employed in local construction industry to facilitate energy program understandings and adoption.
- Manufacturers of building materials/ products taking environmental impacts considerations as the basis of product development.
- Clients\ Donors and consultants should propose contractual requirements to enforce local contractors to use local construction material . The inclusion of environmental

issues in selecting bids or at least in contract conditions or technical qualification can be very effective as well.

- Energy audit should be conducted in continuous form in construction site to review existing practices, investigate energy usage and provide insight into particular inefficient activities so that energy saving systems should be found in place to collect and manage energy data and staff to manage energy use.
- It is required to introduce proper guidelines, tools or techniques based on prior research carried out in the industry to help in decision making for energy related issues.
- Higher education organizations should provide detailed courses about energy management concept and techniques for its construction students.
- Owners\Donors should set the desired level of efficient energy performance for the local contractors to accept them to participate in their projects. it will need to formulate special conditions and specifications to control the industry toward efficient energy construction

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# Appendices

- **Appendix (A) : Questionnaire (English)**
- **Appendix (B): Questionnaire (Arabic)**
- **Appendix (C): Collected factors (Initial)**
- **Appendix (D): Results of experts revision for collected factors**
- **Appendix (E): Factor analysis results**
- **Appendix (F): Criterion related validity results**

# Appendix (A)

# Questionnaire (English)

The Islamic University-Gaza
Higher Education Deanship
Faculty of Engineering
Civil Engineering department
Construction Management

الجامعة الاسلامية – غزة
عمادة الدراسات العليا
كلية الهندسة
قسم الهندسة المدنية
ادارة المشروعات الهندسية

# Questionnaire

## Energy management during construction phase in Gaza Strip Contractors' perspective

**Researcher:**

Abed El Rahman Mahmoud Ayyash

**Supervisor:**

Professor Dr. Adnan Enshassi

Professor of Construction Engineering and Management

October, 2014

# Questionnaire

## Energy management during construction phase in Gaza Strip

**Dear Sir,**

To start, I would like to present my appreciation and thanks to you for taking part of your time and effort to complete this questionnaire.

This questionnaire aims to study the energy management during onsite construction in the construction sector at Gaza Strip. It as part of thesis tried to establish a start or a beginning step toward the contractor efficient use of energy during onsite construction through reviewing local contractors awareness and application level of energy management and identifying the major drivers, barriers and activities to adopt energy management and saving energy in local construction industry from the viewpoint of the local contractors.

This is part of partial fulfillment of the requirements for degree of Master of Science in construction management from Islamic University.

All information in the questionnaire will be used for research with complete commitment for absolute secrecy to your information.

**Contents of Questionnaire:-**

**Section 1:** Respondent and company general information.
**Section 2:** Local contractors level of awareness about energy management.
**Section 3:** Local contractors degree of practice of energy saving and management.
**Section 4:** Major drivers enhancing the local contractors to adopt energy management strategies in construction project in Gaza Strip.
**Section 5:** Key barriers to the implementation of energy management during project construction in Gaza Strip.
**Section 6:** Best activities to save energy during project construction.
.

## Definitions involved in the questionnaire:

**Please, review the following description about the major terms used in the questionnaire before answering the questions.**

- **Energy management** is " the systematic use of management and technology to improve an organization's energy performance".
- **Sustainability or Sustainable development** is " development that meets the needs of the present without compromising the ability of future generations to meet their own needs by the creation and responsible management of a healthy built environment based on resource efficient and ecological principles".
- **Green Technology** is " the development and application of products, equipment and systems used to conserve the natural environment and resources, which minimize and reduces the negative impact of human activities".
- **A voluntary agreement** is "a commitment for an industrial partner or association to achieve a specified energy efficiency improvement potential over a defined period". It is a contract between the government (or another regulating agency) and a private company, association of companies or other institution .
- **Energy Performance Contracts** is " a turnkey service, sometimes compared to design/build construction contracting which provides customers with a comprehensive set of energy efficiency, renewable energy and distributed generation measures . The contractor, typically an energy service company (ESCO), guarantees certain energy savings for a location over a specified period; implements the appropriate energy efficiency improvements; and is paid from the estimated energy cost reductions achieved through the energy savings
- **GHG Emissions** is " the emissions arising as a result of the energy used during onsite construction primarily arise from consumption of fossil fuel energy sources the main emitted gas of is Carbone Dioxide ($CO_2$)".

**Eng. Abdelrahman Mahmoud Ayyash**
**Islamic University**

**Section 1 : Respondent and company general information.**

Please put (x) on the box in front of the selected choice

**1. Your education level.**

☐ Bachelor ☐ Postgraduate studies

**2. Your experience in the construction works (Years).**

☐ From 1 to less than 3 years ☐ From 5 to less than 10 years ☐ From 3 to less than 5 years ☐ More than 10

**3. Your company classification class according to the Palestinian contractors union (PCU).**

☐ First class ☐ Second class ☐ Third class

**4. Your company experience in the construction industry.**

☐ From 1 to less than 3 years ☐ From 5 to less than 10 years ☐ From 3 to less than 5 years ☐ More than 10

**5. Your company size ( number of employees).**

☐ Less than 10 ☐ From 11 to 30 ☐ From 31 to 50 ☐ More than 50

**6. Types of implemented projects through your company in the last ten years.**

☐ Residential ☐ Infrastructure ☐ Public buildings ☐ Environmental

**7. Number of executed projects in the last 10 years by your company.**

☐ 10 Projects or less ☐ 11-20 Projects than 2 ☐ 21-30 Projects ☐ More than 30

**8. Total value of executed projects during the last five years (Million dollars):**

☐ Less than 1 ☐ From 1 to less 5 ☐ From 2 to less than 5 ☐ More than 5

## Section 2 : Local contractors level of awareness/knowledge of energy management.

According to your previous knowledge, indicate at what level you are agree on the accuracy of each one of the following statements which are related to energy issues. Please, put (X) in the box of the selected level of your knowledge on a five-point scale.

| No. | Energy management awareness feature | Strongly disagree | Disagree | Neutral | Agree | Strongly agree |
|---|---|---|---|---|---|---|
| FEM1 | Onsite energy costs represent an important part of the project overall costs. | ☐ | ☐ | ☐ | ☐ | ☐ |
| FEM2 | Increased onsite energy use may result in different negative environmental impacts. | ☐ | ☐ | ☐ | ☐ | ☐ |
| FEM3 | GHG emissions are the highest negative environmental impact associated with energy use during onsite construction. | ☐ | ☐ | ☐ | ☐ | ☐ |
| FEM4 | There is gap between knowledge and application of energy efficiency in local construction industry. | ☐ | ☐ | ☐ | ☐ | ☐ |
| FEM5 | Energy management is one component of the sustainability concept. | ☐ | ☐ | ☐ | ☐ | ☐ |
| FEM6 | Energy management improves the company performance (competitive advantage). | ☐ | ☐ | ☐ | ☐ | ☐ |
| FEM7 | Application of energy management affects the project management method/style. | ☐ | ☐ | ☐ | ☐ | ☐ |
| FEM8 | Energy management is one of the construction business ethics. | ☐ | ☐ | ☐ | ☐ | ☐ |
| FEM9 | Energy management highly reduces overall project cost. | ☐ | ☐ | ☐ | ☐ | ☐ |
| FEM10 | Energy management highly reduces the negative environmental impacts of the project. | ☐ | ☐ | ☐ | ☐ | ☐ |

**Section 3 : Local contractors degree of practice of energy saving and management in the construction projects.**

The table below lists a number of the basic principles of any energy management and saving program , Please, indicate at what level your company applying each of these principles in its activities and projects. Put (X) in the box of the selected level of application on a five-point scale.

| No. | Energy management application requirement | Never applied | Rarely applied | Sometimes applied | Often applied | Always applied |
|---|---|---|---|---|---|---|
| REM1 | My company preparing an environmental management program for each project. | ☐ | ☐ | ☐ | ☐ | ☐ |
| REM2 | My company conducting energy audit and accounting for its construction works to record and report energy consumption and saving opportunities. | ☐ | ☐ | ☐ | ☐ | ☐ |
| REM3 | My company providing a strategy to save energy for each project. | ☐ | ☐ | ☐ | ☐ | ☐ |
| REM4 | My company preparing an energy management plan for each project to save energy during project construction . | ☐ | ☐ | ☐ | ☐ | ☐ |
| REM5 | My company establishing an energy saving objectives and targets for all construction works. | ☐ | ☐ | ☐ | ☐ | ☐ |
| REM6 | My company identifying unique key performance indicators related to energy issues during project construction. | ☐ | ☐ | ☐ | ☐ | ☐ |
| REM7 | My company presenting energy management as one component of its written policy. | ☐ | ☐ | ☐ | ☐ | ☐ |
| REM8 | My company setting a monitoring system for energy use during onsite works. | ☐ | ☐ | ☐ | ☐ | ☐ |
| REM9 | My company conducting periodic revision of significant historical data related to energy aspects for construction works. | ☐ | ☐ | ☐ | ☐ | ☐ |
| REM10 | My company conducting regular assessment of its future energy needs. | ☐ | ☐ | ☐ | ☐ | ☐ |
| REM11 | My company regularly assessing the compliance and committing to all legal obligations and other regulatory requirements related to energy aspects for construction industry. | ☐ | ☐ | ☐ | ☐ | ☐ |

| No. | Energy management application requirement | Never applied | Rarely applied | Sometimes applied | Often applied | Always applied |
|---|---|---|---|---|---|---|
| REM12 | My company hiring a specialized committee or person responsible for all energy issues during construction works. | ☐ | ☐ | ☐ | ☐ | ☐ |
| REM13 | My company providing the required experienced personnel, as well as technical and financial resources to save energy during construction works. | ☐ | ☐ | ☐ | ☐ | ☐ |
| REM14 | My company introducing incentives for the employees to efficient energy use during construction works. | ☐ | ☐ | ☐ | ☐ | ☐ |
| REM15 | My company creating and using energy use manual to save energy during construction works. | ☐ | ☐ | ☐ | ☐ | ☐ |
| REM16 | My company providing specialized energy management training programs for its employees. | ☐ | ☐ | ☐ | ☐ | ☐ |
| REM17 | My company providing onsite awareness programs and tools to efficient energy use during construction works. | ☐ | ☐ | ☐ | ☐ | ☐ |

**Section 4: The major drivers enhancing local contractors to adopt energy management during project construction .**

Thinking of why local construction companies have implemented or would implement energy management during project construction. Please, put (X) in the box of the selected efficiency level of each one of the following drivers on a five-point scale.

| No. | Driver to adopt energy management | Ineffective | Low effective | Moderate effective | High effective | Very high effective |
|---|---|---|---|---|---|---|
| DEM1 | Existence of government regulations related to energy consumption and saving issues for construction industry. | ☐ | ☐ | ☐ | ☐ | ☐ |
| DEM2 | Strength and enforcement of the governmental requirements for onsite construction energy saving. | ☐ | ☐ | ☐ | ☐ | ☐ |
| DEM3 | Contractor energy performance is one criteria of the company rating in local construction sector . | ☐ | ☐ | ☐ | ☐ | ☐ |

| No. | Driver to adopt energy management | Ineffective | Low effective | Moderate effective | High effective | Very high effective |
|---|---|---|---|---|---|---|
| DEM4 | Imposed governmental tax for energy use and emissions on construction companies. | ☐ | ☐ | ☐ | ☐ | ☐ |
| DEM5 | Contract conditions containing specific environmental requirements | ☐ | ☐ | ☐ | ☐ | ☐ |
| DEM6 | Increased education level of the contractor employees. | ☐ | ☐ | ☐ | ☐ | ☐ |
| DEM7 | Construction employees awareness of onsite energy use and problems. | ☐ | ☐ | ☐ | ☐ | ☐ |
| DEM8 | Existence of sustainability policy within the contractor organization. | ☐ | ☐ | ☐ | ☐ | ☐ |
| DEM9 | Availability of experts for energy efficiency in construction industry | ☐ | ☐ | ☐ | ☐ | ☐ |
| DEM10 | Adoption of energy performance contracts (EPC) in local construction market. | ☐ | ☐ | ☐ | ☐ | ☐ |
| DEM11 | Availability of long term energy management strategies within the construction companies. | ☐ | ☐ | ☐ | ☐ | ☐ |
| DEM12 | Top management support to sustainable, energy management and saving activities. | ☐ | ☐ | ☐ | ☐ | ☐ |
| DEM13 | Contractor willingness to satisfy client/donor requirements regarding energy issues. | ☐ | ☐ | ☐ | ☐ | ☐ |
| DEM14 | Availability and frequency of internal training on energy management | ☐ | ☐ | ☐ | ☐ | ☐ |
| DEM15 | Availability of information on successfully implemented energy management practices in construction. | ☐ | ☐ | ☐ | ☐ | ☐ |
| DEM16 | Government support for researchers in energy management in construction industry. | ☐ | ☐ | ☐ | ☐ | ☐ |
| DEM17 | Availability of different energy types, sources and alternatives in local market. | ☐ | ☐ | ☐ | ☐ | ☐ |
| DEM18 | Rising energy prices in local market. | ☐ | ☐ | ☐ | ☐ | ☐ |
| DEM19 | Cost saving gained from adopted energy management strategies. | ☐ | ☐ | ☐ | ☐ | ☐ |

| No. | Driver to adopt energy management | Ineffective | Low effective | Moderate effective | High effective | Very high effective |
|---|---|---|---|---|---|---|
| DEM20 | High energy amounts and costs required during onsite works in the project. | ☐ | ☐ | ☐ | ☐ | ☐ |
| DEM21 | Decrease price levels of energy saving technology for construction industry. | ☐ | ☐ | ☐ | ☐ | ☐ |
| DEM22 | Availability of the financial support for energy saving strategies/plans and investments. | ☐ | ☐ | ☐ | ☐ | ☐ |
| DEM23 | Improvement of the company competitive advantage and reputation as a result of adopting energy management in its projects. | ☐ | ☐ | ☐ | ☐ | ☐ |
| DEM24 | Improved onsite working conditions. | ☐ | ☐ | ☐ | ☐ | ☐ |
| DEM25 | Availability of building code requirements for energy saving and management. | ☐ | ☐ | ☐ | ☐ | ☐ |
| DEM26 | Availability of new energy saving solutions, products and tools in local market. | ☐ | ☐ | ☐ | ☐ | ☐ |

## Section 5: The key barriers to the implementation of energy management in the contracting companies of Gaza Strip.

We would like to understand what makes it difficult to local construction contracting companies to adopt energy management principles and saving strategies. Please, put (X) in the box of the selected agreement level about the importance of each one of the following barriers on a five-point scale.

| No. | Barriers to the implementation of energy management | Strongly disagree | Disagree | Neutral | Agree | Strongly agree |
|---|---|---|---|---|---|---|
| BEM1 | Lack of governmental legislations for environment protection and energy conservation in construction sector. | ☐ | ☐ | ☐ | ☐ | ☐ |
| BEM2 | No specific person or committee assigned to deal with onsite energy issues. | ☐ | ☐ | ☐ | ☐ | ☐ |
| BEM3 | Lack of government support/ incentives for energy management in construction industry. | ☐ | ☐ | ☐ | ☐ | ☐ |
| BEM4 | Lack of energy management codes and regulation in construction. | ☐ | ☐ | ☐ | ☐ | ☐ |

| No. | Barriers to the implementation of energy management | Strongly disagree | Disagree | Neutral | Agree | Strongly agree |
|---|---|---|---|---|---|---|
| BEM5 | Lack of audit and quantitative evaluation tools for the energy performance of the construction companies . | ☐ | ☐ | ☐ | ☐ | ☐ |
| BEM6 | High competition between the local contracting companies working in the construction sector. | ☐ | ☐ | ☐ | ☐ | ☐ |
| BEM7 | Fragmentation of the construction process (Increased industry parties and divided processes). | ☐ | ☐ | ☐ | ☐ | ☐ |
| BEM8 | Difficulties to access technical information and expertise related to energy management in construction. | ☐ | ☐ | ☐ | ☐ | ☐ |
| BEM9 | The contract documents do not impose any special conditions/specifications for onsite energy management. | ☐ | ☐ | ☐ | ☐ | ☐ |
| BEM10 | Company senior management doesn't provide support for energy saving activities | ☐ | ☐ | ☐ | ☐ | ☐ |
| BEM11 | Company management lack interest in onsite energy costs and consumption issues. | ☐ | ☐ | ☐ | ☐ | ☐ |
| BEM12 | Additional costs needed to improve the company energy efficiency. | ☐ | ☐ | ☐ | ☐ | ☐ |
| BEM13 | The company lacks long-term vision and it is short-term oriented. | ☐ | ☐ | ☐ | ☐ | ☐ |
| BEM14 | The company lacks of procedures or strategies to promote sustainable construction | ☐ | ☐ | ☐ | ☐ | ☐ |
| BEM15 | Poor enforcement of the governmental legislations related to energy issues in construction industry. | ☐ | ☐ | ☐ | ☐ | ☐ |
| BEM16 | The company lacks of ethical standards and corporate social responsibility. | ☐ | ☐ | ☐ | ☐ | ☐ |
| BEM17 | Tight project duration makes the management concerned about the time required to adopt energy management practices. | ☐ | ☐ | ☐ | ☐ | ☐ |
| BEM18 | Lack of the company staff awareness on the importance of energy management during onsite construction. | ☐ | ☐ | ☐ | ☐ | ☐ |
| BEM19 | Lack of the client/donor awareness of the importance of energy management during onsite construction. | ☐ | ☐ | ☐ | ☐ | ☐ |

| No. | Barriers to the implementation of energy management | Strongly disagree | Disagree | Neutral | Agree | Strongly agree |
|---|---|---|---|---|---|---|
| BEM20 | Resistance to change from traditional practices to more energy efficient practices. | ☐ | ☐ | ☐ | ☐ | ☐ |
| BEM21 | Management believe that there is no/little scope for the company energy performance improvement . | ☐ | ☐ | ☐ | ☐ | ☐ |
| BEM22 | Conflicts of interest within the project members (owner/consultant/contractor). | ☐ | ☐ | ☐ | ☐ | ☐ |
| BEM23 | Lack of technical skills\knowledge on construction energy management technologies. | ☐ | ☐ | ☐ | ☐ | ☐ |
| BEM24 | Lack of training and education in energy management, sustainable design and construction. | ☐ | ☐ | ☐ | ☐ | ☐ |
| BEM25 | Lack of demonstration examples on energy management in construction industry | ☐ | ☐ | ☐ | ☐ | ☐ |
| BEM26 | High costs of energy management options (measures/technologies). | ☐ | ☐ | ☐ | ☐ | ☐ |
| BEM27 | Construction energy costs are not sufficiently important compared with other costs. | ☐ | ☐ | ☐ | ☐ | ☐ |
| BEM28 | Lack of budget funding to adopt energy management practices and technologies. | ☐ | ☐ | ☐ | ☐ | ☐ |
| BEM29 | Low profit margins gained from adopting energy management practices. | ☐ | ☐ | ☐ | ☐ | ☐ |
| BEM30 | Lack of innovative energy technologies/equipment in local market. | ☐ | ☐ | ☐ | ☐ | ☐ |
| BEM31 | Uncertain local economic environment. | ☐ | ☐ | ☐ | ☐ | ☐ |

**Section 6: The best energy management activities to save energy during project construction.**

The table below lists the most popular energy management activities in industry and construction. We want to indicate at what level each activity will help to save energy during project construction, if applied. From your point of view, put (X) in the box of the selected usefulness level of each one of the following activities on a five-point scale.

| No. | Energy management activities | Unuseful | Low useful | Moderate useful | High useful | Very high useful |
|---|---|---|---|---|---|---|
| SEM1 | Applying the governmental regulations requirements related to construction energy use. | ☐ | ☐ | ☐ | ☐ | ☐ |
| SEM2 | Adopting of the governmental fiscal measures related to onsite construction energy issues. | ☐ | ☐ | ☐ | ☐ | ☐ |
| SEM3 | Adopting of the available energy code requirements for construction industry. | ☐ | ☐ | ☐ | ☐ | ☐ |
| SEM4 | Motivate the company employees to apply more onsite energy saving practices. | ☐ | ☐ | ☐ | ☐ | ☐ |
| SEM5 | Adoption of more energy efficient construction methods as opposed to traditional construction methods during construction phase. | ☐ | ☐ | ☐ | ☐ | ☐ |
| SEM6 | Participating in environmental friendly projects as possible. | ☐ | ☐ | ☐ | ☐ | ☐ |
| SEM7 | Selecting subcontractors who are experienced in energy issues and management in construction . | ☐ | ☐ | ☐ | ☐ | ☐ |
| SEM8 | Setting a quantitative targets for onsite energy use and saving in each activity of the project. | ☐ | ☐ | ☐ | ☐ | ☐ |
| SEM9 | Developing scientific, reasonable energy action plan for the project to make full use of onsite energy and resources. | ☐ | ☐ | ☐ | ☐ | ☐ |
| SEM10 | Development of adequate energy database for the company projects. | ☐ | ☐ | ☐ | ☐ | ☐ |
| SEM11 | Conducting energy audits on the construction site to identify energy use and energy saving opportunities. | ☐ | ☐ | ☐ | ☐ | ☐ |
| SEM12 | Systematic review and analysis for the energy consumption of onsite activities and equipment. | ☐ | ☐ | ☐ | ☐ | ☐ |

| No. | Energy management activities | Unuseful | Low useful | Moderate useful | High useful | Very high useful |
|---|---|---|---|---|---|---|
| SEM13 | Optimization of the transportation of raw materials and equipment to and within the site. | ☐ | ☐ | ☐ | ☐ | ☐ |
| SEM14 | Closer onsite supervision and quality control on energy issues. | ☐ | ☐ | ☐ | ☐ | ☐ |
| SEM15 | Collect information on available energy saving systems, technologies and policies in local construction sector. | ☐ | ☐ | ☐ | ☐ | ☐ |
| SEM16 | Establishing good onsite communications between project staff about energy matters during construction phase. | ☐ | ☐ | ☐ | ☐ | ☐ |
| SEM17 | Employing a specialized team or person responsible for all energy issues during onsite works. | ☐ | ☐ | ☐ | ☐ | ☐ |
| SEM18 | Detailed reporting of the company onsite energy activities. | ☐ | ☐ | ☐ | ☐ | ☐ |
| SEM19 | Use of a monitoring system for energy use during onsite works. | ☐ | ☐ | ☐ | ☐ | ☐ |
| SEM20 | Conducting periodic meetings and training programs for the contractors staff in energy conservation systems/technologies. | ☐ | ☐ | ☐ | ☐ | ☐ |
| SEM21 | Identification and revision of the performance standards for the equipment used onsite . | ☐ | ☐ | ☐ | ☐ | ☐ |
| SEM22 | Frequent examination of the energy efficiency of all equipment used on construction site. | ☐ | ☐ | ☐ | ☐ | ☐ |
| SEM23 | Reducing the unnecessary use of energy consuming equipment and machines used during onsite construction. | ☐ | ☐ | ☐ | ☐ | ☐ |
| SEM24 | Replacement of high energy consuming equipment with lower energy consuming equipment. | ☐ | ☐ | ☐ | ☐ | ☐ |
| SEM25 | Replacement of onsite mechanical equipment with the use of manual labor where applicable. | ☐ | ☐ | ☐ | ☐ | ☐ |
| SEM26 | Practicing of onsite construction methods leading to lower material use . | ☐ | ☐ | ☐ | ☐ | ☐ |
| SEM27 | Selecting where possible only local sources of materials supply. | ☐ | ☐ | ☐ | ☐ | ☐ |
| SEM28 | Increasing the use of recycled building materials. | ☐ | ☐ | ☐ | ☐ | ☐ |

| No. | Energy management activities | Unuseful | Low useful | Moderate useful | High useful | Very high useful |
|---|---|---|---|---|---|---|
| SEM29 | Reducing excessive material and wastage during onsite construction. | ☐ | ☐ | ☐ | ☐ | ☐ |
| SEM30 | Using available energy saving technologies and solutions during onsite construction. | ☐ | ☐ | ☐ | ☐ | ☐ |
| SEM31 | Utilization of renewable energies and green technologies for onsite production, transport and performance. | ☐ | ☐ | ☐ | ☐ | ☐ |
| SEM32 | Software development for onsite energy monitoring and evaluation. | ☐ | ☐ | ☐ | ☐ | ☐ |
| SEM33 | Using onsite energy manual (detailed work instructions) to save energy during onsite construction. | ☐ | ☐ | ☐ | ☐ | ☐ |

*End,,,,,,,*

*Thank you.*

# Appendix (B)

# Questionnaire (Arabic)

الجامعة الاسلامية – غزة
عمادة الدراسات العليا
كلية الهندسة
قسم الهندسة المدنية
ادارة المشروعات الهندسية

The Islamic University-Gaza
Higher Education Deanship
Faculty of Engineering
Civil Engineering department
Construction Management

# استبيان
# ادارة الطاقة خلال مرحلة تنفيذ الانشاءات في قطاع غزة من وجهة نظر المقاولين

وذلك كمتطلب من البحث التكميلي لنيل درجة الماجستير في ادارة المشاريع الهندسية

**الباحث**

عبد الرحمن محمود مصطفى عياش

**المشرف**

بوفيسور دكتور عدنان انشاصي

بروفيسور هندسة وادارة الانشاءات

أكتوبر - 2014

# استبيان

## إدارة الطاقة في خلال مرحلة تنفيذ الانشاءات في قطاع غزة من وجهة نظر المقاولين

**الأخ الكريم/**

**السلام عليكم ورحمة الله وبركاته ,,,,,,**

**أود أولا أن أقدم لسياتكم الشكر الجزيل لتخصيصكم جزء من وقتكم لهذه الرسالة واكمال هذا الاستبيان .**

**موضوع الدراسة :**

تعتبر الطاقة مورد هام ورئيسي لدفع عجلة التنمية للأمام في أي دولة أو مؤسسة , لذلك اتجهت جميع جهود المشرعين والباحثين وغيرهم نحو الحفاظ عليها واستغلالها بالشكل الأمثل وتقليل أي اثار بيئية نتيجة استخدامها . وكما باقي الصناعات فإن صناعة الانشاءات تعتمد بشكل أساسي في جميع أنشطتها على موارد الطاقة المختلفة خصوصا الانشطة التي تتعلق بالتنفيذ وانشاء المشروع حيث يكون فيها المقاول هو المحرك الرئيسي لجميع الموارد والانشطة في هذه المرحلة .

هذا الاستبيان يهدف لدراسة ادارة الطاقة في مواقع الانشاءات خلال مرحلة التنفيذ في صناعة الانشاءات في قطاع غزة من وجهة نظر شركات المقاولات المحلية وهو يعتبر جزء من رسالة ماجستير متكاملة تهدف لإيجاد نقطة بداية وانطلاق لجذب انتباه المقاولين المحليين نحو تحسين أداء شركاتهم في مجال الطاقة , خصوصا خلال مرحلة التنفيذ في الموقع وذلك من خلال استكشاف مدى وعي ومعرفة العاملين في شركات المقاولات المحلية بإدارة الطاقة ومبادئها ومدى تطبيقهم للأسس التي تبنى عليها ادارة الطاقة.

هذه الدراسة تحاول أيضا تحديد أكثر العوامل التي دفعت أو ممكن أن تدفع شركات المقاولات المحلية لتطبيق إدارة الطاقة خلال أنشطتها وخصوصا في مرحلة الانشاء. بجانب ذلك تستكشف هذه الدراسة أهم العوامل التي من الممكن أن تعيق تطبيق إدارة الطاقة ومبادئها في صناعة الانشاءات المحلية وأيضا تحديد أفضل الممارسات التي يمكن تطبيقها لتوفير الطاقة في مواقع الانشاء .

**جميع المعلومات الواردة في هذا الاستبيان ستستخدم لأغراض البحث العلمي فقط مع التزام الباحث الكامل بالحفاظ على سرية المعلومات الخاصة بالشركة والأفراد وعدم استخدامها لأي أغراض أخرى دون إذن مسبق منهم .**

### مكونات الاستبيان:

- **الجزء الأول** : معلومات خاصة بالأشخاص والشركات المشاركة بالاستبيان.
- **الجزء الثاني** : مستوى معرفة المقاولين المحليين بإدارة الطاقة.
- **الجزء الثالث :** مستوى تطبيق المقاولين المحليين لمبادي وممارسات ادارة الطاقة.
- **الجزء الرابع :** العوامل الرئيسية التي تدفع المقاولين المحليين لتطبيق ادارة الطاقة خلال مرحلة التنفيذ بالموقع.
- **الجزء الخامس** : العوائق الرئيسية التي تمنع المقاولين المحليين من تطبيق ادارة الطاقة خلال مرحلة التنفيذ بمواقع الانشاءات.
- **الجزء السادس :** أهم الممارسات المتعلقة بإدارة الطاقة التي تؤدي لحفظ الطاقة أثناء التنفيذ بالموقع.

## تعريفات يشملها الاستبيان :

**الرجاء مراجعة التعريفات والتوضيحات اللاحقة والتي وردت في الاستبيان قبل الاجابة عن اسئلة الاستبيان :**

- **إدارة الطاقة "Energy management"** : هي عملية ممنهجة لاستخدام الادارة والتكنلوجيا لتحسين أداء الشركة بمجال الطاقة .

- **الاستدامة أو الانشاء المستدام "Sustainability-Sustainable construction"** : هو التطور الذي يؤدي لتحقيق الحاجات الحالية بدون التأثير على قدرة الشركة المستقبلية لتحقيق حاجاتها من خلال الابتكار والادارة المسؤولة لبيئة صحية بالاعتماد على المبادئ والاسس الفاعلة لإدارة الموارد وحفظ البيئة .

- **التكنلوجيا الخضراء "Green technology"** : هي عملية تطوير واستخدام المنتجات والمعدات والانظمة التي تستخدم لحفظ الموارد والبيئة الطبيعية والتي تؤدي لتقليل الاثار السلبية لأنشطة الانسان.

- **الاتفاقات الطوعية "Voluntary agreement"** : هي عبارة عن التزام من الشركة أو الصناعة ككل لتحسين أداؤها بمجال الطاقة خلال فترة محددة وتتم من خلال عقد بين الحكومة أو أي مؤسسة تشريعية مع شركة ما أو مجموعة شركات أو قطاع صناعة محدد .

- **عقود أداء الطاقة "Energy Performance Contracts (EPC)"** : هي عقود متكاملة شبيهة بعقد التصميم والتنفيذ بصناعة الانشاءات تهدف لتوفير مجموعة شاملة من وسائل الطاقة المتجددة والأكثر كفاءة للطاقة . و يكون فيها المقاول عبارة عن شركة تقدم خدمات الطاقة بحيث يضمن مقدار معين من توفير الطاقة خلال فترة محددة في مكان ما من خلال تطبيق التحسينات المناسبة لأداء الطاقة ويحصل مقابل ذلك على مبالغ مالية مقابل التوفير في تكاليف الطاقة في المشروع.

- **غازات الدفيئة المنبعثة "GHG Emissions"**: هي الغازات التي تنبعث نتيجة استخدام الطاقة خصوصا الطاقة المستخرجة من الارض وأهمها غاز ثاني أكسيد الكربون.

**م.عبد الرحمن محمود عياش**

**الجامعة الاسلامية – غزة**

# الجزء الأول : معلومات عامة.

الرجاء وضع علامة (X) أمام الخيار أو الخيارات الذي يتناسب مع اجابتك

**1- مستوى تعليمك الأكاديمي**

☐ بكالوريوس ☐ دراسات عليا

**2- خبرتك في صناعة الانشاءات (بالسنوات)**

☐ أقل من 3 ☐ من 3 إلى أقل من 5 ☐ من 5 الى أقل من 10 ☐ أكثر من 10

**3- تصنيف الشركة التي تعمل فيها حسب تصنيف اتحاد المقاولين الفلسطينيين**

☐ درجة أولى ☐ درجة ثانية ☐ درجة ثالثة

**4- خبرة الشركة التي تعمل فيها في صناعة الانشاءات (بالسنوات)**

☐ أقل من 3 ☐ من 3 إلى أقل من 5 ☐ من 5 الى أقل من 10 ☐ أكثر من 10

**5- حجم المؤسسة التي تعمل فيها (عدد الموظفين )**

☐ أقل من 10 ☐ من 11 إلى 30 ☐ من 31 الى 50 ☐ أكثر من 50

**6- نوع المشاريع التي نفذتها الشركة خلال العشر سنوات السابقة**

☐ مباني سكنية ☐ مشاريع بنية تحتية ☐ مشاريع مباني عامة ☐ مشاريع بيئية

**7- عدد المشاريع التي تم تنفيذها خلال العشر سنوات السابقة**

☐ أقل من 10 ☐ من 10 الى 20 ☐ من 21الى 30 ☐ أكثر من 30

**8- قيمة المشاريع التي تم تنفيذها خلال العشر سنوات السابقة ( مليون دولار)**

☐ أقل من 1 ☐ من 1 إلى أقل من 2 ☐ من 2 إلى أقل من 5 ☐ أكثر من 5

## الجزء الثاني : مستوى وعي ومعرفة المقاولين المحليين بإدارة الطاقة.

في الجدول أدناه عدد من العبارات التي تتعلق بإدارة الطاقة وصناعة الانشاءات . بناء على معرفتك السابقة بقضايا الطاقة والبيئة وادارة الطاقة , يرجى تحديد مدى موافقتك على صحة كل عبارة من هذه العبارات بوضع علامة (X) في الصندوق الذي يناسب مستوى الموافقة الذي تختاره وذلك بناء على مستويات التقييم الخمس الموضحة في الجدول .

| م. | معيار المعرفة بإدارة الطاقة | غير موافق بشدة | غير موافق | محايد | موافق | موافق بشدة |
|---|---|---|---|---|---|---|
| 1 | تمثل تكاليف الطاقة في الموقع جزءا كبيرا من اجمالي تكاليف المشروع | ☐ | ☐ | ☐ | ☐ | ☐ |
| 2 | استخدام الطاقة المتزايد في موقع الانشاء يؤدي للعديد من الآثار البيئية السلبية . | ☐ | ☐ | ☐ | ☐ | ☐ |
| 3 | غازات الدفيئة المنبعثة (GHG Emissions) هي أكثر أثر بيئي سلبي مرتبط باستخدام الطاقة خلال الانشاء في الموقع. | ☐ | ☐ | ☐ | ☐ | ☐ |
| 4 | يوجد فجوة كبيرة بين المعرفة والتطبيق في الاستخدام الأمثل للطاقة في صناعة الانشاءات المحلية. | ☐ | ☐ | ☐ | ☐ | ☐ |
| 5 | إدارة الطاقة (Energy Management) هي أحد عناصر مفهوم الاستدامة (Sustainability). | ☐ | ☐ | ☐ | ☐ | ☐ |
| 6 | تطبيق إدارة الطاقة يؤدي لتحسين أداء الشركة (زيادة القدرة التنافسية). | ☐ | ☐ | ☐ | ☐ | ☐ |
| 7 | تطبيق إدارة الطاقة يؤثر على طريقة وشكل إدارة المشروع . | ☐ | ☐ | ☐ | ☐ | ☐ |
| 8 | الالتزام بإدارة الطاقة يمثل أحد أخلاقيات صناعة الانشاءات. | ☐ | ☐ | ☐ | ☐ | ☐ |
| 9 | تطبيق إدارة الطاقة يؤدي لتقليل التكلفة الاجمالية للمشروع لحد كبير. | ☐ | ☐ | ☐ | ☐ | ☐ |
| 10 | تطبيق إدارة الطاقة يقلل إلى حد كبير من الآثار البيئية السلبية للمشروع. | ☐ | ☐ | ☐ | ☐ | ☐ |

## الجزء الثالث: مستوى تطبيق المقاولين المحليين لإدارة وتوفير الطاقة فى المشاريع الانشائية.

في الجدول أدناه عدد من الأسس والمبادئ التي تبنى عليها برامج إدارة الطاقة . بناء على الوضع في الشركة التي تعمل فيها , يرجى تحديد لأي مستوى تقوم الشركة بتطبيق كل مبدأ من هذه المبادئ في انشطتها ومشاريعها بوضع علامة (X) في الصندوق الذي يناسب المستوى الذي تختاره بناء على مستويات التقييم الخمس الموضحة في الجدول .

| م. | مبادئ تطبيق ادارة الطاقة | لا تطبق مطلقا | تطبق نادرا | تطبق أحيانا | تطبق غالبا | تطبق دائما |
|---|---|---|---|---|---|---|
| 1 | تقوم الشركة بإعداد برنامج خاص بكل مشروع لإدارة البيئة . | ☐ | ☐ | ☐ | ☐ | ☐ |
| 2 | تقوم الشركة بإجراء تدقيق ومحاسبة لجميع قضايا الطاقة أثناء تنفيذ المشروع لكي توثق وتسجل كميات استهلاك الطاقة وفرص توفيرها . | ☐ | ☐ | ☐ | ☐ | ☐ |
| 3 | تقوم الشركة بإعداد استراتيجية لتوفير الطاقة لكل مشروع. | ☐ | ☐ | ☐ | ☐ | ☐ |
| 4 | تقوم الشركة بإعداد خطة لإدارة الطاقة لكل مشروع بهدف توفير استخدام الطاقة أثناء التنفيذ. | ☐ | ☐ | ☐ | ☐ | ☐ |
| 5 | تقوم الشركة بتحديد غايات و أهداف محددة لتوفير استخدام الطاقة في جميع الأعمال أثناء التنفيذ. | ☐ | ☐ | ☐ | ☐ | ☐ |
| 6 | تقوم الشركة بتحديد مؤشرات الأداء الرئيسية المتعلقة بجوانب استهلاك الطاقة أثناء التنفيذ. | ☐ | ☐ | ☐ | ☐ | ☐ |
| 7 | تعتبر ادارة الطاقة كأحد عناصر سياسة الشركة المكتوبة. | ☐ | ☐ | ☐ | ☐ | ☐ |
| 8 | تقوم الشركة بتوفير نظام لمراقبة استخدام الطاقة أثناء التنفيذ في الموقع. | ☐ | ☐ | ☐ | ☐ | ☐ |
| 9 | تقوم الشركة بإجراء مراجعة دورية للبيانات القديمة المتوفرة والتي تتعلق بجوانب استخدام الطاقة في أثناء التنفيذ. | ☐ | ☐ | ☐ | ☐ | ☐ |
| 10 | تقوم الشركة بإجراء تقييم منتظم لاحتياجاتها المستقبلية من الطاقة. | ☐ | ☐ | ☐ | ☐ | ☐ |
| 11 | تقوم الشركة بشكل دوري بتقييم مدى التزامها بجميع المتطلبات القانونية و التنظيمية المتعلقة بقضايا الطاقة في صناعة الانشاءات. | ☐ | ☐ | ☐ | ☐ | ☐ |
| 12 | تقوم الشركة بتعيين لجنة متخصصة أو شخص محدد ليكون مسؤول عن جميع قضايا الطاقة أثناء التنفيذ. | ☐ | ☐ | ☐ | ☐ | ☐ |
| 13 | تقوم الشركة بتوفير طاقم عمل ذو خبرة عالية، وكذلك توفير الموارد التقنية والمالية لتحسين استخدام الطاقة خلال تنفيذ المشروع. | ☐ | ☐ | ☐ | ☐ | ☐ |
| 14 | تقوم الشركة بتقديم الحوافز للعاملين لتحسين استخدام الطاقة أثناء التنفيذ . | ☐ | ☐ | ☐ | ☐ | ☐ |

| م. | مبادئ تطبيق ادارة الطاقة | لا تطبق مطلقا | تطبق نادرا | تطبق أحيانا | تطبق غالبا | تطبق دائما |
|---|---|---|---|---|---|---|
| 15 | تقوم الشركة بإنشاء واستخدام دليل للطاقة (كتيب تعليمات مفصلة) لتوفير الطاقة أثناء التنفيذ . | ☐ | ☐ | ☐ | ☐ | ☐ |
| 16 | تقوم الشركة بتوفير برامج التدريب المتخصصة في إدارة الطاقة لموظفيها. | ☐ | ☐ | ☐ | ☐ | ☐ |
| 17 | تقوم الشركة بتوفير برامج ووسائل التوعية في موقع العمل للاستخدام الطاقة بالشكل الأمثل. | ☐ | ☐ | ☐ | ☐ | ☐ |

## الجزء الرابع : الدوافع الرئيسية لتطبيق إدارة الطاقة في مرحلة الانشاء في شركات المقاولات المحلية.

في الجدول أدناه عدد من العوامل التي دفعت أو من الممكن أن تدفع شركات المقاولات المحلية لتطبيق إدارة الطاقة في أنشطتها ومشاريعها خصوصا أثناء مرحلة التنفيذ ، يرجى تقييم فعالية كل دافع من هذه لدوافع في تشجيع شركات المقاولات المحلية لتطبيق إدارة الطاقة ضمن أنشطتها في الموقع ,وذلك بوضع علامة (X ) في الصندوق أمام مستوى الفعالية الذي تختاره حسب مستويات التقييم الخمس الموضحة في الجدول.

| م. | دوافع تطبيق ادارة الطاقة | غير مؤثر | مؤثر بدرجة قليلة | مؤثر بدرجة متوسطة | مؤثر بدرجة عالية | مؤثر بدرجة عالية جدا |
|---|---|---|---|---|---|---|
| 1 | وجود تشريعات حكومية تتعلق بجوانب استهلاك الطاقة وتوفيرها في صناعة الانشاءات. | ☐ | ☐ | ☐ | ☐ | ☐ |
| 2 | الشدة والالزامية لتطبيق المتطلبات الحكومية لتوفير الطاقة أثناء التنفيذ في الموقع. | ☐ | ☐ | ☐ | ☐ | ☐ |
| 3 | توفر متطلبات في كود الانشاءات تتعلق بتوفير الطاقة ادارتها خلال التنفيذ. | ☐ | ☐ | ☐ | ☐ | ☐ |
| 4 | فرض الحكومة ضريبة محددة على شركات المقاولات بسبب استخدام الطاقة والانبعاثات المتعلقة باستخدامها في مواقع العمل. | ☐ | ☐ | ☐ | ☐ | ☐ |
| 5 | تطبيق عقود أداء الطاقة ( Energy performance contracts "EPC") في صناعة الانشاءات المحلية. | ☐ | ☐ | ☐ | ☐ | ☐ |
| 6 | وجود نظام تصنيف للشركات في قطاع الانشاءات يأخذ بالحسبان كفاءة الشركة في استخدام الطاقة في مشاريعها | ☐ | ☐ | ☐ | ☐ | ☐ |
| 7 | المالك\الممول يعتبر كفاءة استخدام الطاقة في شركة المقاولات كأحد معايير اختيارها للحصول على المشروع. | ☐ | ☐ | ☐ | ☐ | ☐ |
| 8 | توفر الدعم الحكومي للباحثين في مجال إدارة الطاقة في صناعة الانشاءات. | ☐ | ☐ | ☐ | ☐ | ☐ |
| 9 | توفر الخبراء المختصين بكفاءة استخدام الطاقة في صناعة الانشاءات. | ☐ | ☐ | ☐ | ☐ | ☐ |

| م. | دوافع تطبيق ادارة الطاقة | غير مؤثر | مؤثر بدرجة قليلة | مؤثر بدرجة متوسطة | مؤثر بدرجة عالية | مؤثر بدرجة عالية جدا |
|---|---|---|---|---|---|---|
| 10 | وجود استراتيجية للاستدامة (Sustainability) ضمن سياسة شركة المقاولات. | ☐ | ☐ | ☐ | ☐ | ☐ |
| 11 | توفر استراتيجيات طويلة المدى لإدارة الطاقة في شركات المقاولات. | ☐ | ☐ | ☐ | ☐ | ☐ |
| 12 | دعم الإدارة العليا للشركة للبرامج والأنشطة المتعلقة بالاستدامة وادارة وتوفير الطاقة في مشاريعها . | ☐ | ☐ | ☐ | ☐ | ☐ |
| 13 | توفر الرغبة لدى المقاول لتحقيق متطلبات المالك/ الممول المتعلقة باستخدام الطاقة وادارتها في المشروع . | ☐ | ☐ | ☐ | ☐ | ☐ |
| 14 | زيادة وعي ومعرفة العاملين في الشركة بجوانب استخدام الطاقة ومشاكلها خلال التنفيذ في الموقع. | ☐ | ☐ | ☐ | ☐ | ☐ |
| 15 | توفر المعلومات حول نماذج حية لتطبيق ادارة الطاقة في مشاريع انشائية تم تنفيذها مسبقا. | ☐ | ☐ | ☐ | ☐ | ☐ |
| 16 | ارتفاع المستوى التعليمي للعاملين في الشركة | ☐ | ☐ | ☐ | ☐ | ☐ |
| 17 | توفير وتكرار التدريب داخل الشركة في مجال إدارة الطاقة | ☐ | ☐ | ☐ | ☐ | ☐ |
| 18 | ارتفاع أسعار الطاقة في السوق المحلي. | ☐ | ☐ | ☐ | ☐ | ☐ |
| 19 | التوفير في تكاليف المشروع نتيجة تطبيق استراتيجيات إدارة الطاقة. | ☐ | ☐ | ☐ | ☐ | ☐ |
| 20 | حاجة المشروع لكميات كبيرة وتكلفة عالية من الطاقة خلال التنفيذ في الموقع | ☐ | ☐ | ☐ | ☐ | ☐ |
| 21 | انخفاض اسعار التكنولوجيا الموفرة للطاقة المتعلقة بصناعة الانشاءات. | ☐ | ☐ | ☐ | ☐ | ☐ |
| 22 | توفر الدعم المالي للاستثمارات والخطط والاستراتيجيات المتعلقة بإدارة الطاقة وتوفيرها . | ☐ | ☐ | ☐ | ☐ | ☐ |
| 23 | تحسن القدرة التنافسية وسمعة الشركة نتيجة لاعتماد إدارة الطاقة في مشاريعها | ☐ | ☐ | ☐ | ☐ | ☐ |
| 24 | تحسن ظروف العمل في الموقع . | ☐ | ☐ | ☐ | ☐ | ☐ |
| 25 | توفر مختلف أصناف وبدائل الطاقة في السوق المحلي | ☐ | ☐ | ☐ | ☐ | ☐ |
| 26 | توفر مختلف الوسائل والموارد والادوات المتعلقة بتوفير الطاقة في الانشاءات في السوق المحلي. | ☐ | ☐ | ☐ | ☐ | ☐ |

**الجزء الخامس : العوائق الرئيسية أمام تنفيذ إدارة الطاقة خلال مرحلة الانشاء في الموقع في قطاع غزة.**

في الجدول أدناه عدد من الأسباب التي تحد أو تمنع شركات المقاولات المحلية من تطبيق إدارة الطاقة في مشاريعها خصوصا خلال مرحلة التنفيذ . يرجى تحديد مدى موافقتك على كل عائق من هذه العوائق كسبب لمنع أو تأخير تطبيق إدارة الطاقة ,وذلك بوضع علامة (X ) في الصندوق أمام مستوى الموافقة الذي تختاره حسب مستويات التقييم الخمس الموضحة في الجدول.

| م. | عوائق تطبيق ادارة الطاقة | غير موافق بشدة | غير موافق | محايد | موافق | موافق بشدة |
|---|---|---|---|---|---|---|
| 1 | عدم وجود تشريعات حكومية تتعلق بحماية البيئة وحفظ الطاقة في صناعة الانشاءات. | ☐ | ☐ | ☐ | ☐ | ☐ |
| 2 | ضعف وعدم الزامية التشريعات الحكومية المتعلقة بجوانب استخدام الطاقة في صناعة الانشاءات. | ☐ | ☐ | ☐ | ☐ | ☐ |
| 3 | عدم توفر الدعم والحوافز الحكومية لتطبيق ادارة الطاقة في صناعة الانشاءات. | ☐ | ☐ | ☐ | ☐ | ☐ |
| 4 | عدم وجود كود محدد ونظام يختص بإدارة الطاقة في صناعة الانشاءات. | ☐ | ☐ | ☐ | ☐ | ☐ |
| 5 | عدم توفر أدوات التدقيق والتقييم الكمية لأداء الطاقة في شركات الانشاءات. | ☐ | ☐ | ☐ | ☐ | ☐ |
| 6 | وجود منافسة عالية بين شركات المقاولات المحلية العاملة في صناعة الانشاءات. | ☐ | ☐ | ☐ | ☐ | ☐ |
| 7 | تشتت صناعة الانشاءات ( تعدد الأطراف العاملة في المشروع وعدم ترابط مراحل المشروع). | ☐ | ☐ | ☐ | ☐ | ☐ |
| 8 | تضارب المصالح بين أطراف المشروع (المالك/ الاستشاري/ المقاول). | ☐ | ☐ | ☐ | ☐ | ☐ |
| 9 | وثائق العقد لا تفرض أي شروط أو مواصفات خاصة بإدارة الطاقة أثناء التنفيذ. | ☐ | ☐ | ☐ | ☐ | ☐ |
| 10 | عدم دعم الادارة العليا للشركة للأنشطة المتعلقة بتوفير الطاقة. | ☐ | ☐ | ☐ | ☐ | ☐ |
| 11 | عدم اهتمام إدارة الشركة العليا بتكاليف الطاقة في الموقع و جوانب إدارتها. | ☐ | ☐ | ☐ | ☐ | ☐ |
| 12 | التكاليف الإضافية اللازمة لتحسين كفاءة أداء الطاقة في الشركة. | ☐ | ☐ | ☐ | ☐ | ☐ |
| 13 | افتقار الشركة لرؤية طويلة الأجل وجميع برامجها قصيرة الأجل. | ☐ | ☐ | ☐ | ☐ | ☐ |
| 14 | عدم وجود إجراءات أو استراتيجيات محددة في الشركة لتعزيز تطبيق مفهوم الانشاء المستدام (Sustainable Construction) في مشاريعها. | ☐ | ☐ | ☐ | ☐ | ☐ |

| م. | عوائق تطبيق ادارة الطاقة | غير موافق بشدة | غير موافق | محايد | موافق | موافق بشدة |
|---|---|---|---|---|---|---|
| 15 | افتقار الشركة لمعايير أخلاقية محددة تتعلق باستخدام الطاقة بجانب افتقارها للمسؤولية الاجتماعية أثناء تنفيذ المشاريع . | ☐ | ☐ | ☐ | ☐ | ☐ |
| 16 | عدم قيام الشركة بتوظيف شخص محدد أو طاقم محدد للتعامل مع مسائل الطاقة في الموقع. | ☐ | ☐ | ☐ | ☐ | ☐ |
| 17 | الحاجة لمدة أطول للتخطيط ولاعتماد التكنلوجيا والمواد الموفرة للطاقة | ☐ | ☐ | ☐ | ☐ | ☐ |
| 18 | الافتقار للوعي والمعرفة لدى العاملين في الشركة بأهمية إدارة الطاقة خلال مرحلة الانشاء. | ☐ | ☐ | ☐ | ☐ | ☐ |
| 19 | افتقار المالك\الممول للوعي والمعرفة بأهمية إدارة الطاقة أثناء مرحلة الانشاء. | ☐ | ☐ | ☐ | ☐ | ☐ |
| 20 | مقاومة الشركة للتغيير من الممارسات التقليدية إلى ممارسات أكثر كفاءة في استخدام الطاقة. | ☐ | ☐ | ☐ | ☐ | ☐ |
| 21 | قناعة ادارة الشركة بعدم وجود مجال لتحسين أداء الطاقة في الشركة. | ☐ | ☐ | ☐ | ☐ | ☐ |
| 22 | صعوبة الحصول على المعلومات الفنية و المعلومات حول الخبرات العملية المتعلقة بإدارة الطاقة في صناعة الانشاءات. | ☐ | ☐ | ☐ | ☐ | ☐ |
| 23 | الافتقار إلى المهارات والمعرفة الفنية حول استخدام تقنيات إدارة الطاقة في صناعة الانشاءات. | ☐ | ☐ | ☐ | ☐ | ☐ |
| 24 | الافتقار للتدريب والتعليم في مجال إدارة الطاقة والتصميم والانشاء المستدام. | ☐ | ☐ | ☐ | ☐ | ☐ |
| 25 | عدم توفر نماذج حية و توضيحية لإدارة الطاقة في صناعة الانشاءات. | ☐ | ☐ | ☐ | ☐ | ☐ |
| 26 | التكاليف العالية للخيارات المتعلقة تطبيق إدارة الطاقة (الاجراءات/ التقنيات) | ☐ | ☐ | ☐ | ☐ | ☐ |
| 27 | تكاليف الطاقة في عملية الانشاء ليست مهمة بما فيه الكفاية مقارنة مع غيرها من تكاليف المشروع. | ☐ | ☐ | ☐ | ☐ | ☐ |
| 28 | انخفاض التمويل من ميزانية الشركة لتطبيق ممارسات وتقنيات إدارة الطاقة. | ☐ | ☐ | ☐ | ☐ | ☐ |
| 29 | انخفاض هامش الربح في المشاريع نتيجة تطبيق ممارسات إدارة الطاقة. | ☐ | ☐ | ☐ | ☐ | ☐ |
| 30 | عدم توفر التقنيات والمعدات الحديثة و المختصة باستخدام الطاقة في السوق المحلية. | ☐ | ☐ | ☐ | ☐ | ☐ |
| 31 | عدم استقرار البيئة الاقتصادية المحلية. | ☐ | ☐ | ☐ | ☐ | ☐ |

## الجزء السادس : أفضل الممارسات لتوفير استخدام الطاقة خلال التنفيذ في الموقع في صناعة الانشاءات.

في الجدول أدناه عدد من الممارسات والانشطة الشائعة المتعلقة بإدارة الطاقة في الصناعات خصوصا صناعة الانشاءات . يرجى تحديد لأي مستوى يمكن أن يكون تطبيق كل ممارسة من هذه الممارسات مفيد في توفير الطاقة أثناء التنفيذ في الموقع , وذلك بوضع علامة (X ) في الصندوق أمام مستوى الفائدة الذي تختاره بناء على مستويات التقييم الخمس الموضحة في الجدول.

| م. | ممارسات توفير استخدام الطاقة في الموقع | غير مفيد | مفيد بدرجة منخفضة | مفيد بدرجة متوسطة | مفيد بدرجة عالية | مفيد بدرجة عالية جدا |
|---|---|---|---|---|---|---|
| 1 | تطبيق متطلبات القوانين الحكومية المتعلقة باستخدام الطاقة في صناعة الانشاءات. | ☐ | ☐ | ☐ | ☐ | ☐ |
| 2 | تطبيق الشركة لمتطلبات الحكومة المالية التي تتعلق بجوانب استخدام الطاقة في مواقع الانشاء. | ☐ | ☐ | ☐ | ☐ | ☐ |
| 3 | تطبيق الشركة لمتطلبات كود الطاقة المتوفرة في صناعة الانشاءات المحلية . | ☐ | ☐ | ☐ | ☐ | ☐ |
| 4 | تحفيز عاملي الشركة على تطبيق ممارسات موفرة للطاقة بشكل أكبر في موقع الانشاء. | ☐ | ☐ | ☐ | ☐ | ☐ |
| 5 | تطبيق أساليب انشاء موفرة بشكل أكبر للطاقة بدلا من أساليب الانشاء التقليدية خلال مرحلة التنفيذ. | ☐ | ☐ | ☐ | ☐ | ☐ |
| 6 | العمل على المشاركة في المشاريع الصديقة للبيئة | ☐ | ☐ | ☐ | ☐ | ☐ |
| 7 | إعداد تقارير تفصيلية حول الأنشطة المتعلقة بالطاقة اثناء التنفيذ في مشاريعها. | ☐ | ☐ | ☐ | ☐ | ☐ |
| 8 | تحديد أهداف كمية محددة لاستخدام الطاقة وتوفيرها لكل نشاط في المشروع. | ☐ | ☐ | ☐ | ☐ | ☐ |
| 9 | إعداد خطة عمل تنفيذية للمشروع على أسس علمية ومنطقية لاستخدام الموارد و الطاقة في الموقع بشكل كامل . | ☐ | ☐ | ☐ | ☐ | ☐ |
| 10 | إعداد قاعدة بيانات كافية تتعلق باستخدام الطاقة اثناء التنفيذ في مشاريع الشركة. | ☐ | ☐ | ☐ | ☐ | ☐ |
| 11 | إجراء تدقيق على الجوانب المتعلقة بالطاقة في مواقع التنفيذ لتحديد استخداماتها وفرص توفيرها. | ☐ | ☐ | ☐ | ☐ | ☐ |
| 12 | إجراء مراجعة منظمة وتحليل ممنهج لاستخدامات الطاقة في الأنشطة والمعدات في الموقع . | ☐ | ☐ | ☐ | ☐ | ☐ |
| 13 | الاستخدام الأمثل للطاقة في عملية نقل المواد الخام والمعدات الى موقع العمل وداخله . | ☐ | ☐ | ☐ | ☐ | ☐ |
| 14 | الاشراف الصارم والتحكم بجودة استخدام الطاقة من قبل ادارة الشركة اثناء التنفيذ في الموقع | ☐ | ☐ | ☐ | ☐ | ☐ |
| 15 | جمع المعلومات عن أنظمة وتكنلوجيا توفير الطاقة المتاحة في سوق الإنشاءات المحلي. | ☐ | ☐ | ☐ | ☐ | ☐ |

| م. | ممارسات توفير استخدام الطاقة في الموقع | غير مفيد | مفيد بدرجة منخفضة | مفيد بدرجة متوسطة | مفيد بدرجة عالية | مفيد بدرجة عالية جدا |
|---|---|---|---|---|---|---|
| 16 | توفير تواصل ميداني جيد بين العاملين في موقع العمل حول جوانب استخدام الطاقة اثناء التنفيذ. | ☐ | ☐ | ☐ | ☐ | ☐ |
| 17 | تعيين فريق متخصص أو شخص مسؤول عن جميع قضايا الطاقة أثناء التنفيذ في الموقع. | ☐ | ☐ | ☐ | ☐ | ☐ |
| 18 | عقد اجتماعات وبرامج تدريبية دورية لطاقم الشركة حول أنظمة وتقنيات توفير استخدام على الطاقة. | ☐ | ☐ | ☐ | ☐ | ☐ |
| 19 | تطبيق نظام مراقبة على استخدامات الطاقة أثناء التنفيذ في الموقع | ☐ | ☐ | ☐ | ☐ | ☐ |
| 20 | اختيار مقاولي باطن لديهم الخبرة الكافية في قضايا استخدام الطاقة وادارتها في صناعة الانشاءات. | ☐ | ☐ | ☐ | ☐ | ☐ |
| 21 | تحديد ومراجعة معايير الأداء للمعدات والاليات المستخدمة في الموقع. | ☐ | ☐ | ☐ | ☐ | ☐ |
| 22 | الفحص الدوري لكفاءة المعدات في استخدام الطاقة أثناء التنفيذ في الموقع . | ☐ | ☐ | ☐ | ☐ | ☐ |
| 23 | الحد من الاستخدام غير الضروري للمعدات والاليات التي تستهلك كميات كبيرة من الطاقة. | ☐ | ☐ | ☐ | ☐ | ☐ |
| 24 | استبدال المعدات ذات الاستهلاك المرتفع للطاقة بمعدات أقل استهلاكا. | ☐ | ☐ | ☐ | ☐ | ☐ |
| 25 | استبدال المعدات الميكانيكية في الموقع بالعمل اليدوي عند توفر الامكانية. | ☐ | ☐ | ☐ | ☐ | ☐ |
| 26 | تطبيق اساليب الانشاء الموفرة لاستهلاك المواد المختلفة المستخدمة في الانشاء في الموقع. | ☐ | ☐ | ☐ | ☐ | ☐ |
| 27 | استخدام المواد المحلية الصنع في عملية الانشاء كلما توفرت الامكانية. | ☐ | ☐ | ☐ | ☐ | ☐ |
| 28 | زيادة استخدام مواد البناء المعاد تدويرها (المعاد تصنيعها). | ☐ | ☐ | ☐ | ☐ | ☐ |
| 29 | خفض كمية الزيادة في المواد وتقليل الفاقد من المواد المستخدمة في الموقع خلال التنفيذ. | ☐ | ☐ | ☐ | ☐ | ☐ |
| 30 | استخدام التقنيات والحلول التكنلوجية المتاحة للعمل على توفير استخدام الطاقة خلال التنفيذ. | ☐ | ☐ | ☐ | ☐ | ☐ |
| 31 | الاستفادة من الطاقة المتجددة والتكنولوجيا الخضراء في عملية والانشاء والنقل خلال التنفيذ. | ☐ | ☐ | ☐ | ☐ | ☐ |
| 32 | تطوير البرمجيات لدى الشركة لرصد وتقييم الطاقة في الموقع. | ☐ | ☐ | ☐ | ☐ | ☐ |
| 33 | تطبيق دليل الطاقة في الموقع (تعليمات العمل المفصلة) لتوفير استخدام الطاقة خلال التنفيذ . | ☐ | ☐ | ☐ | ☐ | ☐ |

# Appendix (C)

# Collected factors\variables

**(Initial)**

Table (C.1): Collected Energy management awareness feature

| **Energy management awareness feature** | **References** |
| --- | --- |
| Onsite energy costs represent an important part of the project overall costs. | De Groot et al. (2001); WEC (2004); Gorp (2004); Russell (2005) ; Wai et al. (2006); UNIDO (2007); Glavič and Lukman (2007); Sustainability Victoria (2007); Suliman and Omran (2009); Fisher and Bristow (2009); Wai (2009); Doukas et al. (2009); Yen and Wai (2010); UNIDO (2011); Wyk et al. (2011); Liu (2012); Shi et al. (2013); Cagno et al. (2013); Kibert (2008); Turner and Doty (2009); Apeaning (2012); ClimateWorks-Australia (2013) |
| Increased onsite energy use may result in different negative environmental impacts. | |
| GHG emissions are the highest negative environmental impact associated with energy use during onsite construction. | |
| There is gap between knowledge and application of energy efficiency in local construction industry. | |
| Energy management is one component of the sustainability concept. | |
| Energy management improves the company performance (competitive advantage). | |
| Application of energy management affects the project management method/style. | |
| Energy management is one of the construction business ethics. | |
| Energy management highly reduces overall project cost. | |
| Energy management highly reduces the negative environmental impacts of the project. | |

Table (C.2): Collected energy management application requirements

| No. | Energy management application requirement | References |
|---|---|---|
| 1 | Have an energy policy | Christoffersen et al. (2006) ; UNIDO (2007); Turner  and Doty (2009) ; Scheihing (2009); Kahlenborn et al. (2010); |
| 2 | Having a written energy policy | Ates and Durakbasa (2012) |
| 3 | Having an official energy manager | UNIDO (2007) ; Kahlenborn et al. (2010); Ates and Durakbasa (2012) |
| 4 | Setting an energy saving target | Kannan and Boie (2003); Christoffersen et al. (2006) ; Scheihing (2009); The Carbon Trust (2011); Ates and Durakbasa (2012) |
| 5 | Have set quantitative energy saving goals | Christoffersen et al. (2006) |
| 6 | Energy management plan | UNIDO (2007) ;Turner  and Doty (2009); Scheihing (2009) |
| 7 | Planning | Kahlenborn et al. (2010); The Carbon Trust (2011) |
| 8 | Creation of an Energy Manual | UNIDO (2007); Scheihing (2009) |
| 9 | Have an energy strategy | The Carbon Trust (2011) |
| 10 | Identification of key performance indicators,  unique to the company | UNIDO (2007); Scheihing (2009); Kahlenborn et al. (2010) |
| 11 | Assess future energy needs | Turner  and Doty (2009); Kahlenborn et al. (2010) |
| 12 | Staff  training and engagement | Kannan and Boie (2003); Kahlenborn et al. (2010); The Carbon Trust (2011) |
| 13 | Energy audit and accounting | Kannan and Boie (2003);Turner  and Doty (2009); |
| 14 | Continuous energy accounting | Kahlenborn et al. (2010) |
| 15 | Mapping of energy use | Kahlenborn et al. (2010) |
| 16 | Having implemented energy efficiency projects | UNIDO (2007) ; Ates and Durakbasa (2012) |
| 17 | Analysis of energy historical data | Kannan and Boie (2003);Turner  and Doty (2009); Kahlenborn et al. (2010); The Carbon Trust (2011) |

Table (C.2): Collected energy management application requirements "Continued"

| No. | Energy management application requirement | References |
|---|---|---|
| 18 | Have energy records | Turner and Doty (2009) |
| 19 | Monitoring and analysing energy use | The Carbon Trust (2011) |
| 20 | Make energy recommendations | Turner and Doty (2009) |
| 21 | Periodic reporting of progress | UNIDO (2007) |
| 22 | Educating key employees | Kahlenborn et al. (2010) |
| 23 | Evaluate program effectiveness | Turner and Doty (2009) |
| 24 | Engineering analysis and investments proposals based on feasibility studies | Kannan and Boie, (2003) |
| 25 | Assessing the compliance with legal obligations | Kahlenborn et al. (2010) |
| 26 | Identify outside assistance | Turner and Doty (2009) |
| 27 | Energy-efficient purchases | Kahlenborn et al. (2010) |
| **Other references used in requirements collection** | | |
| Shen and Tam (2002); WEC (2004); Reffat (2004); Wai et al. (2006) Subrahmanya (2006); ISO (2008); Al-Mofleh et al. (2009); Tan et al. (2011) Suliman and Omran (2009) | | |

Table (C.3): Collected energy management application drivers

| No. | Driver for energy management | De Groot et al. (2001) | UNEP (2006) | Pino et al. (2006) | Christofferset et al., 2006 | Reddy and Assenza (2007) | Rohdin et al. (2007) | Rettab and Brik (2008) | Apeaning (2012) | Bond and Perrett (2012) | Liu et al. (2012) | Apeaning and Thollander (2013) | Davies et al. (2013a) | Cagno and Trianni, 2013 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Rising energy costs | | | | | √ | | | | √ | | √ | √ | √ |
| 2 | Cost saving from improved energy management | | √ | √ | √ | | | | | √ | | | | |
| 3 | Cost reductions resulting from lowered energy use | √ | √ | | | | | | √ | | | √ | | |
| 4 | The introduction or increasing of fees on energy resources consumed | | | | | | | | | | | | | √ |
| 5 | Decrease in technology price levels | | | | | √ | | | | | | | | √ |
| 6 | Differentiate from competitors | | | | | | | √ | | | | | | |
| 7 | Energy management level of competitors | | | | | | | | | | √ | | | √ |
| 8 | Establish a competitive advantage | | | √ | | | √ | √ | | √ | | √ | | |
| 9 | Influence of industrial association of the same sector | | | | | | | | | | √ | | | |
| 10 | Expand to new markets | | | | | | | √ | | | | | | |
| 11 | Improve company brand | | | | | | | √ | | | | | | |
| 12 | Improved reputation / recognition | | √ | | | | | | | | | | | |
| 13 | Take care of environment | | | | √ | | | | | | | | | |
| 14 | Green Image of Corporation | √ | | | √ | | | | | | | | | |
| 15 | Environmental management system | | | | | | | | √ | | | √ | | |

Table (C.3): Collected energy management application drivers "Continued"

| No. | Driver for energy management | De Groot et al. (2001) | UNEP (2006) | Pino et al. (2006) | Christofferset et al., 2006 | Reddy and Assenza (2007) | Rohdin et al. (2007) | Rettab and Brik (2008) | Apeaning (2012) | Bond and Perrett (2012) | Liu et al. (2012) | Apeaning and Thollander (2013) | Davies et al. (2013a) | Cagno and Trianni, 2013 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 16 | Environmental company profile | | | | | | √ | | √ | | | √ | | |
| 17 | Improved working conditions | | | | | | | | | | | √ | | |
| 18 | Improved staff pride / morale | | √ | | √ | | | | | | | | | |
| 19 | People with real ambition | | | | | | √ | | √ | | | √ | | |
| 20 | Tenant satisfaction and productivity | | | | | | | | | √ | | | | √ |
| 21 | Top manager's support to energy saving activities | | | | | | | | | | √ | | | √ |
| 22 | Long-rang plans within sector | √ | | | | | | | | | | | | |
| 23 | Long term energy strategy | | | | | | √ | | | | | √ | | |
| 24 | Energy Efficient Scheme | | | | | | | | | | | | √ | |
| 25 | Info on practices (Having information on successfully-implemented practices) | | | | | | | | | | | | | √ |
| 26 | Energy performance contracts | | | | | | | | | | | | | √ |
| 27 | Local Governmental regulations | | √ | | | √ | | √ | | | | √ | | √ |
| 28 | Governmental measures intended to drive Greenhouse Gas (GHG) (namely CO2) and energy consumption reduction | | | | | | | | | | | | √ | |
| 29 | Governmental policy | | | | | | | | | √ | | | | |

Table (C.3): Collected energy management application drivers “Continued”

| No. | Driver for energy management | De Groot et al. (2001) | UNEP (2006) | Pino et al. (2006) | Christofferset et al., 2006 | Reddy and Assenza (2007) | Rohdin et al. (2007) | Rettab and Brik (2008) | Apeaning (2012) | Bond and Perrett (2012) | Liu et al. (2012) | Apeaning and Thollander (2013) | Davies et al. (2013a) | Cagno and Trianni, 2013 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 30 | Carbon taxation | | | | | | | | | | | | √ | |
| 31 | Energy tax | | | | | | | | √ | | | √ | | |
| 32 | Emissions tax | | | | | | | | √ | | | √ | | |
| 33 | Strength of governmental requirements of energy saving | | | | | | | | | | √ | | | |
| 34 | Awareness of internal energy use and problems | | | | | √ | | √ | | | √ | | | |
| 35 | Increased education level of employees | | | | | √ | | | | √ | √ | | | |
| 36 | Frequency of internal training on energy saving | | | | | | | | | | √ | | | |
| 37 | Greater availability of green products | | | | | | | | | √ | | | | |
| 38 | Satisfy customers requirements | | √ | √ | √ | | | √ | | | | | | |
| 39 | Commitment to sustainability | | | | | | | √ | | | | | | |
| 40 | Willingness to improve energy efficiency | | | | | | | | | | √ | | | |
| 41 | Company’s intention to invest in new facility for energy saving | | | | | | | | | | √ | | | |
| 42 | Industry rating system | | | | | | | | | √ | | | | |
| 43 | Building code requirements | | | | | | | | | √ | | | | |
| 44 | Improved compliance with corporate environmental targets | | √ | | | | | | | | | | | |

Table (C.3): Collected energy management application drivers “Continued”

| No. | Driver for energy management | De Groot et al. (2001) | UNEP (2006) | Pino et al. (2006) | Christofferset et al., 2006 | Reddy and Assenza (2007) | Rohdin et al. (2007) | Rettab and Brik (2008) | Apeaning (2012) | Bond and Perrett (2012) | Liu et al. (2012) | Apeaning and Thollander (2013) | Davies et al. (2013a) | Cagno and Trianni, 2013 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 45 | Voluntary agreements with tax exemption | | | | | | | | √ | | | √ | | |
| 46 | Investments Subsides | √ | | | | | | | | | | | | √ |
| 47 | Special financing opportunities for investments | √ | | | | | √ | | | | | | | √ |
| 48 | Non-energy benefits (improved indoor environment, comfort, health, safety, and productivity , labor and time savings | | | | | √ | | | | | | | | √ |
| 49 | Access to energy efficiency experts | | | | | | | | | | | | | √ |
| 50 | Clients (Having clients who are interested in energy efficiency and environmental issues) | | | | | | | | | | | | | √ |
| 51 | Publicly financed energy audit by sector organization expert. | | | | | | | | √ | | | | | |
| 52 | General energy advices through seminar | | | | | | | | √ | | | | | |
| 53 | General energy advices through journal or booklet | | | | | | | | √ | | | | | |

**Other studies used for drivers collection**

Shen and Tam (2002); WBCSD (2008); Rohdin et al. (2007); Reddy and Assenza (2007); Bassioni et al. (2010); UNIDO (2011); Liu (2012); Thollander et al. (2013); Davies et al. (2013b); Venmans (2014); Brunke et al. (2014)

Table (C.4) : Collected energy management adoption barriers

| No. | Barriers for Energy Management | Nadel et al., 1991 | De Groot et al., 2001 | Plessis,2002 | Shafii et al., 2006 | UNEP, 2006 | Rohdin et al., 2007 | Stefan, 2008 | Akinbami and Lawal, 2009 | Balasubramanian, 2012 | Bond and Perrett, 2012 | Apeaning and Thollander, 2013 | Shi et al., 2013 | Hwang and Ng, 2013 | Djokoto et al., 2014 | Zhang et al., 2011 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Corporate culture | | | | | | | √ | | | | | | | | |
| 2 | Our company / Companies' culture does not encourage staff to give suggestions for improvement | | | | | √ | | | | | | | | | | |
| 3 | Our company / Companies do not have targets for energy (only for production) | | | | | √ | | | | | | | | | | |
| 4 | Energy objectives not integrated into operating, maintenance or purchasing procedure | | | | | | √ | | | | | √ | | | | |
| 5 | Lack of Green Supply Chain Management practices in organizations vision | | | | | | | | | √ | | | | | | |
| 6 | Lack of Green Supply Chain Management practices in organizations mission | | | | | | | | | √ | | | | | | |
| 7 | Organizations lack 'long term' vision and are short term oriented | | | | | | | | | √ | | | | | | |
| 8 | Lack of strategy to promote sustainable construction | | | | | | | | | | | | | | √ | |
| 9 | There is a lack of policies, procedures and systems within our company / companies | | | | | √ | | | | | | | | | | |
| 10 | Lack of IT infrastructure systems like environmental monitoring system(EMS) in the organization | | | | | | | | | √ | | | | | | |
| 11 | Lack of ethical standards and corporate social responsibility | | | | | | | | | √ | | | | | | |

Table (C.4) : Collected energy management adoption barriers “Continued”

| No. | Barriers for Energy Management | Nadel et al., 1991 | De Groot et al., 2001 | Plessis,2002 | Shafii et al., 2006 | UNEP, 2006 | Rohdin et al., 2007 | Stefan, 2008 | Akinbami and Lawal, 2009 | Balasubramanian, 2012 | Bond and Perrett, 2012 | Apeaning and Thollander, 2013 | Shi et al., 2013 | Hwang and Ng, 2013 | Djokoto et al., 2014 | Zhang et al., 2011 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 12 | lack of interest | | | | | | | √ | | | | | | | | |
| 13 | Lack of interest in the issue of sustainability | | | √ | | | | | | | | | | | | |
| 14 | Dep./Workers not accountable for energy costs | | | | | | √ | | | | | √ | | | | |
| 15 | Lack of importance of energy consumption in daily business | | | | | | | √ | | | | | | | | |
| 16 | Feeling of 'too complex' to implement Green Supply Chain Management among stakeholders | | | | | | | | | √ | | | | | | |
| 17 | Unwillingness to pay additional costs | | | | | | | | | | √ | | | | | |
| 18 | Low priority given to energy management | | √ | | | | √ | | | | | √ | | | | |
| 19 | Lack of communication and interest among project team members | | | | | | | | | | | | | √ | | |
| 20 | There is a lack of coordination between departments within our company / companies | | | | | √ | | | | | | | | | | |
| 21 | There is a lack of coordination between external organizations | | | | | √ | | | | | | | | | | |
| 22 | Lack of cooperation within the supply chain stakeholders | | | | | | | | | √ | | | | | √ | |
| 23 | Other investments more important | | √ | | | | √ | | | | | √ | | | | |
| 24 | Management finds production more important | | | | | √ | | | | | | | | | | |

Table (C.4) : Collected energy management adoption barriers “Continued”

| No. | Barriers for Energy Management | Nadel et al., 1991 | De Groot et al., 2001 | Plessis,2002 | Shafii et al., 2006 | UNEP, 2006 | Rohdin et al., 2007 | Stefan, 2008 | Akinbami and Lawal, 2009 | Balasubramanian, 2012 | Bond and Perrett, 2012 | Apeaning and Thollander, 2013 | Shi et al., 2013 | Hwang and Ng, 2013 | Djokoto et al., 2014 | Zhang et al., 2011 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 25 | Management believe there is no/little scope for improvement | | | | | √ | | | | | | | | | | |
| 26 | Lack of support from senior management | | | | | | | √ | | √ | | | √ | | | |
| 27 | Lack of leadership and commitment from senior and middle level managers | | | | | | | | | √ | | | | | | |
| 28 | lack of support by employees | | | | | | | √ | | | | | | | | |
| 29 | Lack of staff awareness | | | | | | √ | | | | | √ | | | | |
| 30 | Workers' unaware of the correct methods and procedures | | | | | | | | | | | | | √ | | |
| 31 | Regional ambiguities in the green concept | | | | | | | | | | | | √ | | | |
| 32 | Lack of Awareness on sustainable building | | | | √ | | | | | √ | | | | | | |
| 33 | There is a lack of awareness of the importance of energy efficiency | | | | | √ | | | √ | | | | | | | √ |
| 34 | Lack of Public awareness | | | | | | | | | | | | | | √ | |
| 35 | Lack of owner/occupier awareness | | | | | | | | | | √ | | | | | |
| 36 | Lack of developer awareness | | | | | | | | | | √ | | | | | |
| 37 | Lack of information | √ | | | | √ | | √ | | | | | | | √ | |
| 38 | Poor access to information | | | | | | | | | | √ | | | | | |

Table (C.4) : Collected energy management adoption barriers "Continued"

| No. | Barriers for Energy Management | Nadel et al., 1991 | De Groot et al., 2001 | Plessis,2002 | Shafii et al., 2006 | UNEP, 2006 | Rohdin et al., 2007 | Stefan, 2008 | Akinbami and Lawal, 2009 | Balasubramanian, 2012 | Bond and Perrett, 2012 | Apeaning and Thollander, 2013 | Shi et al., 2013 | Hwang and Ng, 2013 | Djokoto et al., 2014 | Zhang et al., 2011 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 39 | It is difficult to access external technical information and expertise | | | | | √ | | | | | | | | | | |
| 40 | Lack of accurate data | | | √ | | | | | | | | | | | √ | |
| 41 | Poor information quality regarding energy efficiency opportunities | | | | | | √ | | | | | √ | | | | |
| 42 | Difficulties in obtaining information about energy consumption of purchased equipments | | | | | | √ | | | | | √ | | | | |
| 43 | Lack of Design and Construction team | | | | | | | | | | | | | | √ | |
| 44 | There is no specific person or committee dealing with energy at companies | | | | | √ | | | | | | | | | | |
| 45 | Sufficient lack of green architects, consultants, green developers, contractors in the region | | | | | | | | | √ | | | | | | |
| 46 | Lack of technical skills | √ | | | | | √ | | | √ | | √ | | √ | | |
| 47 | Lack of professional knowledge | | | | | √ | | √ | | √ | | | | | √ | |
| 48 | Lack of Professional capabilities/Designers | | | | √ | | | | | | | | | | | |
| 49 | Lack of knowledge on green technology and materials | | | | | | | | | | | | √ | | | |
| 50 | Dearth of skilled manpower and technical know-how | | | | | | | | √ | | | | | | | |
| 51 | Lack of Expertise | | | | | | | | | | | | | | √ | |

Table (C.4) : Collected energy management adoption barriers “Continued”

| No. | Barriers for Energy Management | Nadel et al., 1991 | De Groot et al., 2001 | Plessis,2002 | Shafii et al., 2006 | UNEP, 2006 | Rohdin et al., 2007 | Stefan, 2008 | Akinbami and Lawal, 2009 | Balasubramanian, 2012 | Bond and Perrett, 2012 | Apeaning and Thollander, 2013 | Shi et al., 2013 | Hwang and Ng, 2013 | Djokoto et al., 2014 | Zhang et al., 2011 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 52 | Lack of experience among the stakeholders in executing Green Supply Chain Management | | | | | | | | | √ | | | | | | |
| 53 | Resistance to change from their traditional practices | | | | | √ | | | | √ | | | | √ | √ | |
| 54 | Technological inertia | | | √ | | | | | | | | | | | | |
| 55 | Technical obstructions | | | | | | | √ | | | | | | | | |
| 56 | Lack of innovative technology in manufacturing and construction | | | | | | | | | √ | | | | | √ | |
| 57 | Limited availability of new technology | | | | | | | | | | √ | | | | | |
| 58 | Lack of technology for waste management and recycling | | | | | | | | | √ | | | | | | |
| 59 | Imperfect green technological specifications | | | | | | | | | | | | √ | | | |
| 60 | Unreliable /Unproven technology | √ | | | | | | | | | √ | | | | | |
| 61 | Technology is inappropriate at this site | | | | | | √ | | | | | √ | | | | |
| 62 | Technology will become cheaper | | √ | | | | | | | | | | | | | |
| 63 | No good overview of existing technologies | | √ | | | | | | | | | | | | | |
| 64 | May be new technology will not satisfy future standards | | √ | | | | | | | | | | | | | |
| 65 | Misunderstanding of green technological operations | | | | | | | | | | | | √ | | | |
| 66 | Restrictions of new green production and technology | | | | | | | | | | | | √ | | | |

Table (C.4) : Collected energy management adoption barriers “Continued”

| No. | Barriers for Energy Management | Nadel et al., 1991 | De Groot et al., 2001 | Plessis,2002 | Shafii et al., 2006 | UNEP, 2006 | Rohdin et al., 2007 | Stefan, 2008 | Akinbami and Lawal, 2009 | Balasubramanian, 2012 | Bond and Perrett, 2012 | Apeaning and Thollander, 2013 | Shi et al., 2013 | Hwang and Ng, 2013 | Djokoto et al., 2014 | Zhang et al., 2011 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 67 | Limited availability of green suppliers and information | | | | | | | | | | | | √ | | | |
| 68 | Availability of green material and equipment | √ | | | | | | | | | | | | √ | | |
| 69 | Uncertainty with green material and equipment | | | | | | | | | | | | | √ | | |
| 70 | High cost in green material and equipment | | | | | | | | | | | | | √ | | |
| 71 | Lack of training | | | | | | | | | | | | | | √ | |
| 72 | Lack of Training and Education in Sustainable Design and Construction | | | | √ | | | | | | | | | | | |
| 73 | Lack of training in Green Supply Chain Management | | | | | | | | | √ | | | | | | |
| 74 | Lack of internal sustainability audits within the organization | | | | | | | | | √ | | | | | | |
| 75 | Lack of external sustainability audits of suppliers and contractors | | | | | | | | | √ | | | | | | |
| 76 | Uncertain economic environment | | | √ | | | | | | | | | | | | |
| 77 | Economic environment | | | | | | | √ | | | | | | | | |
| 78 | International crisis and economic down turn | | | | | | | | | √ | | | | | | |
| 79 | The Government does not give financial incentives to become energy efficient | | | | | √ | | | | | | | | | | |
| 80 | Lack of Government support | | | | | | | | | | | | | | √ | |

Table (C.4) : Collected energy management adoption barriers “Continued”

| No. | Barriers for Energy Management | Nadel et al., 1991 | De Groot et al., 2001 | Plessis,2002 | Shafii et al., 2006 | UNEP, 2006 | Rohdin et al., 2007 | Stefan, 2008 | Akinbami and Lawal, 2009 | Balasubramanian, 2012 | Bond and Perrett, 2012 | Apeaning and Thollander, 2013 | Shi et al., 2013 | Hwang and Ng, 2013 | Djokoto et al., 2014 | Zhang et al., 2011 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 81 | Lack of preferential treatment and long term contracts for adopting Green Supply Chain Management from government | | | | | | | | | √ | | | | | | |
| 82 | Lack of government incentives and best practices awards for adopting Green Supply Chain Management | | | | | | | | | √ | | | | | | |
| 83 | lack of environmental incentive | | | | | | | √ | | | | | | | | |
| 84 | Lack of incentives | | | | | | | | | | | | | | √ | |
| 85 | Lack of incentive and motivation | | | | | | | | √ | | √ | | | | | |
| 86 | Management is concerned about the investment costs of energy | | | | | √ | | | | | | | | | | |
| 87 | High initial investment in implementing Green Supply Chain Management | | | | | | | | | √ | | | | | | |
| 88 | Higher investment cost | | | | | | | | | | | | | | √ | |
| 89 | The high cost of proposed measures | | | | | | | √ | | | | | | | | √ |
| 90 | Only new expensive technologies will improve energy efficiency at companies | | | | | √ | | | | | | | | | | |
| 91 | Current installations are sufficiently efficient | | √ | | | | | | | | | | | | | |
| 92 | Higher final cost | | | | | | | | | | | | | | √ | |
| 93 | The higher cost of sustainable building Option | | | | √ | | | | | | | | | | | |

Table (C.4) : Collected energy management adoption barriers “Continued”

| No. | Barriers for Energy Management | Nadel et al., 1991 | De Groot et al., 2001 | Plessis,2002 | Shafii et al., 2006 | UNEP, 2006 | Rohdin et al., 2007 | Stefan, 2008 | Akinbami and Lawal, 2009 | Balasubramanian, 2012 | Bond and Perrett, 2012 | Apeaning and Thollander, 2013 | Shi et al., 2013 | Hwang and Ng, 2013 | Djokoto et al., 2014 | Zhang et al., 2011 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 94 | Additional costs caused by green construction | | | | | | | | | | | | √ | | | |
| 95 | Cost of identifying opportunities, analyzing cost effectiveness and tendering | | | | | | √ | | | | | √ | | | | |
| 96 | Measure costs exceed willingness to pay | √ | | | | | | | | | | | | | | |
| 97 | Cost of staff replacement, retirement, retraining | | | | | | √ | | | | | | | | | |
| 98 | Short payback time | | | | | | | √ | | | | | | | | |
| 99 | Slow return on Investments(ROI) after implementing Green Supply Chain Management | | | | | | | | | √ | | | | | | |
| 100 | High cost Vs. perceived benefits | | | | | | | | | | √ | | | | | |
| 98 | Low profit margins | | | | | | | | | √ | | | | | | |
| 99 | Lack of budget funding | √ | √ | | | | | | | | | √ | | | | |
| 100 | It is difficult to obtain financing for energy efficiency projects | | | | | √ | | | | | | | | | | |
| 101 | Better to wait for subsidies | | √ | | | | | | | | | | | | | |
| 102 | Internal constraints on budget | | √ | | | | | | | | | | | | | |
| 103 | Access to capital | | | | | | √ | | | | | √ | | | | |
| 104 | High competition in the construction sector | | | | | | | | | √ | | | | | | |
| 105 | Conflicts in benefits with competitors | | | | | | | | | | | | √ | | | |

Table (C.4) : Collected energy management adoption barriers "Continued"

| No. | Barriers for Energy Management | Nadel et al., 1991 | De Groot et al., 2001 | Plessis,2002 | Shafii et al., 2006 | UNEP, 2006 | Rohdin et al., 2007 | Stefan, 2008 | Akinbami and Lawal, 2009 | Balasubramanian, 2012 | Bond and Perrett, 2012 | Apeaning and Thollander, 2013 | Shi et al., 2013 | Hwang and Ng, 2013 | Djokoto et al., 2014 | Zhang et al., 2011 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 106 | Risk of investment | | | | | | | | | | | | | | √ | |
| 107 | Unforeseen circumstances in green project | | | | | | | | | | | | | √ | | |
| 108 | Market uncertainty due to project delay, project on hold and cancellation | | | | | | | | | √ | | | | | | |
| 109 | Uncertainty in the performance of green materials and equipment | | | | | | | | | | | | √ | | | |
| 110 | Uncertainty regarding the quality | | √ | | | | | | | | | | | | | |
| 111 | Possible poor performance of equipment | | | | | | √ | | | | | √ | | | | |
| 112 | Technical risks such as risk of production disruptions | | | | | | √ | | | | | √ | | | | |
| 113 | Lack of customer demands for sustainable projects | | | | | | | | | √ | | | | | | |
| 114 | Lack of Demand | | | | | | | | | | | | | | √ | |
| 115 | Law client demand | | | | | | | | | | √ | | | | | |
| 116 | Energy is cheap | | | | | √ | | | | | | | | | | |
| 117 | Energy costs not transparent | | | | | | | √ | | | | | | | | |
| 118 | Inappropriate energy pricing | | | | | | | | √ | | | | | | | |
| 119 | Energy only auxiliary function | | | | | | | √ | | | | | | | | |
| 120 | Energy costs are not sufficiently important | | √ | | | | | | | | | | | | | |

Table (C.4) : Collected energy management adoption barriers "Continued"

| No. | Barriers for Energy Management | Nadel et al., 1991 | De Groot et al., 2001 | Plessis,2002 | Shafii et al., 2006 | UNEP, 2006 | Rohdin et al., 2007 | Stefan, 2008 | Akinbami and Lawal, 2009 | Balasubramanian, 2012 | Bond and Perrett, 2012 | Apeaning and Thollander, 2013 | Shi et al., 2013 | Hwang and Ng, 2013 | Djokoto et al., 2014 | Zhang et al., 2011 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 121 | Energy supply constraint | | | | | | | | √ | | | | | | | |
| 122 | Incremental time caused by green construction | | | | | | | | | | | | √ | | | |
| 123 | Lack of time | | | | | | √ | √ | | | | √ | | | | |
| 124 | Management is concerned about time required to improve energy efficiency | | | | | √ | | | | | | | | | | |
| 125 | More time is required to implement green construction practices onsite | | | | | | | | | | | | | √ | | |
| 126 | Lengthy approval process for new green technologies within the organization | | | | | | | | | | | | | √ | | |
| 127 | The process to obtain approval from top management for investments is long | | | | | √ | | | | | | | | | | |
| 128 | Long decision chains | | | | | | √ | | | | | √ | | | | |
| 129 | Client uses a lot of time in making decision | | | | | | | | | | | | | √ | | |
| 130 | Green consultant delay in providing information | | | | | | | | | | | | | √ | | |
| 131 | Government policy | | | | | | | | | | | | | √ | | |
| 132 | Regulatory barriers | | | | √ | | | | | | | | | | | |
| 133 | Lack of legislation | | | | | | | | √ | | | | | | | |
| 134 | Environmental policies and legislation relating to energy are weak | | | | | √ | | | | | | | | | | |

Table (C.4) : Collected energy management adoption barriers “Continued”

| No. | Barriers for Energy Management | Nadel et al., 1991 | De Groot et al., 2001 | Plessis,2002 | Shafii et al., 2006 | UNEP, 2006 | Rohdin et al., 2007 | Stefan, 2008 | Akinbami and Lawal, 2009 | Balasubramanian, 2012 | Bond and Perrett, 2012 | Apeaning and Thollander, 2013 | Shi et al., 2013 | Hwang and Ng, 2013 | Djokoto et al., 2014 | Zhang et al., 2011 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 135 | Lack of Building Codes and Regulation | | | | | | | | | | | | | | √ | |
| 136 | Lack of sustainability certifications like IS0 14001 | | | | | | | | | √ | | | | | | |
| 137 | Authorities are not strict in enforcing environmental regulations | | | | | √ | | | | | | | | | | |
| 138 | Lack of a measurement tool | | | | | | | | | | | | | | √ | |
| 139 | Lack of quantitative evaluation tools for green performance | | | | | | | | | | | | √ | | | |
| 140 | Benefits of implemented energy efficiency measures are not quantifiable | | | | | √ | | | | | | | | | | |
| 141 | Conflict of interest between consultant and project manager | | | | | | | | | | | | | √ | | √ |
| 142 | Conflicts of interest within the company | | | | | | √ | | | | | √ | | | | |
| 143 | Conflict with the architect over the type of material to be used | | | | | | | | | | | | | √ | | |
| 144 | Lack of integrated research | | | √ | | | | | | | | | | | | |
| 145 | Reduction of structure aesthetic | | | | | | | | | | | | √ | | | |
| 146 | Dependence on promotion by government | | | | | | | | | | | | √ | | | |
| 147 | Lack of demonstration examples | | | | √ | | | | | | | | | | | |

Table (C.4) : Collected energy management adoption barriers “Continued”

| No. | Barriers for Energy Management | Nadel et al., 1991 | De Groot et al., 2001 | Plessis,2002 | Shafii et al., 2006 | UNEP, 2006 | Rohdin et al., 2007 | Stefan, 2008 | Akinbami and Lawal, 2009 | Balasubramanian, 2012 | Bond and Perrett, 2012 | Apeaning and Thollander, 2013 | Shi et al., 2013 | Hwang and Ng, 2013 | Djokoto et al., 2014 | Zhang et al., 2011 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 148 | Better to await experience of colleagues | | √ | | | | | | | | | | | | | |
| 149 | lack of capacity of the construction sector | | | √ | | | | | | | | | | | | |
| 150 | Hassles of implementing efficiency projects | √ | | | | | | | | | | | | | | |
| 151 | Slim Organization | | | | | | √ | | | | | √ | | | | |
| 152 | Energy managers lacks influence | | | | | | √ | | | | | √ | | | | |
| 153 | Increased Documentation | | | | | | | | | | | | | | √ | |
| 154 | Difficulty in comprehending the green specifications in the contract details | | | | | | | | | | | | | √ | | |
| 155 | Difficulty in the selection of subcontractors in providing green construction service | | | | | | | | | | | | | √ | | |
| 156 | Extensive Pre-contract planning | | | | | | | | | | | | | √ | √ | |

**Other studies used for barriers collection**

Worrell and Price (2001a); Shen and Tam (2002); Reddy and Assenza (2007); Kibert (2008); Hwang and Varnas et al. (2009); Tan (2010); Zhang et al. (2011); Shari and Soebarto (2012); Davies et al. (2013b); Rao and Pavan, (2013) ; Cagno et al. (2013); Trianni et al. (2013); Brunke et al. (2014); Djokoto et al.(2014); Venmans (2014); Hee et al. (2014); Powmya and Abidin (2014)

Table (C.5) : Collected best activities for energy saving

| No. | Energy management activity | UNCHS, 1991 | Worrell and Price, 2001b | Plessis,2002 | Ibrik and Mahmoud, 2005 | UNEP, 2006 | Christoffersen et al., 2006 | Capehart et al. 2006 | Shafii et al., 2006 | Sengupta, 2008 | Akinbami and Lawal, 2009 | Xundi et al., 2010 | Chuanzhong and Yingji, 2011 | Tan et al., 2011 | Saravanan, 2011 | UNIDO , 2011 | Bond and Perrett, 2012 | Liu et al., 2012 | Na et al.,2012 | Liu et al., 2014 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Legislative and regulatory support | | | | | | | | | | √ | | | | | | | | | |
| 2 | Energy regulations for energy consumption and direct/ indirect electrical loads | | | | √ | | | | | | | | | | | | | | | |
| 3 | Change in legislation | | | | | | | | | | | | | | | | √ | | | |
| 4 | Government should advocate energy saving and low-carbon lifestyle by flexible economic incentive mechanism | | | | | | | | | | | | √ | | | | | | | |
| 5 | Governments promote perfect incentive mechanisms for energy-saving including taxation relief, duty privilege, financial subsidies | | | | | | | | | | | | √ | | | | | | | |
| 6 | Government should take effective measures to encourage enterprises that belong to high-carbon industry to raise their energy-saving efficiency fundamentally by scientific and technological innovation. | | | | | | | | | | | | √ | | | | | | | |
| 7 | Apply for energy-saving subsidies at national or local level | | | | | | | | | | | | | | | | | √ | | √ |
| 8 | Loans / subsidies for energy efficiency | | | | | √ | | | | | | | | | | | | | | |
| 9 | introducing incentives for energy saving | √ | | | | | | | | | | | | | | | | | | |

Table (C.5) : Collected best activities for energy saving ”Continued”

| No. | Energy management activity | UNCHS, 1991 | Worrell and Price, 2001b | Plessis,2002 | Ibrik and Mahmoud, 2005 | UNEP, 2006 | Christoffersen et al., 2006 | Capehart et al. 2006 | Shafii et al., 2006 | Sengupta, 2008 | Akinbami and Lawal, 2009 | Xundi et al., 2010 | Chuanzhong and Yingji, 2011 | Tan et al., 2011 | Saravanan, 2011 | UNIDO , 2011 | Bond and Perrett, 2012 | Liu et al., 2012 | Na et al.,2012 | Liu et al., 2014 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 10 | More rebates/subsidies | | | | | | | | | | | | | | | | √ | | | |
| 11 | subsidies and tax credits | | √ | | | | | | | | | | | | | | | | | |
| 12 | Providing incentives | √ | | | | | | | | | | | | | | | | | | |
| 13 | Governmental Support for research into energy consumption in the construction process | √ | | | | | | | | | | | | | | | | | | |
| 14 | Industry networks | | | | | √ | | | | | | | | | | | | | | |
| 15 | Optimizing and upgrading industry structure to raise energy-saving efficiency | | | | | | | | | | | | √ | | | | | | | |
| 16 | Building owners and clients should play important roles in disseminating sustainable construction | | | | | | | | √ | | | | | | | | | | | |
| 17 | Improvement of the building construction process as opposed to the traditional methods | | | | | | | | √ | | | | | | | | | | | |
| 18 | The development of an energy code | | | √ | | | | | | | | | | | | | | | | |
| 19 | Building code change | | | | | | | | | | | | | | | | √ | | | |
| 20 | Building certification | | | | | | | | | | | | | | | | √ | | | |
| 21 | Finding new and better ways to increase returns from energy investments through research and development | | | | | | | √ | | | | | | | | | | | | |

Table (C.5) : Collected best activities for energy saving "Continued"

| No. | Energy management activity | UNCHS, 1991 | Worrell and Price, 2001b | Plessis,2002 | Ibrik and Mahmoud, 2005 | UNEP, 2006 | Christoffersen et al., 2006 | Capehart et al. 2006 | Shafii et al., 2006 | Sengupta, 2008 | Akinbami and Lawal, 2009 | Xundi et al., 2010 | Chuanzhong and Yingji, 2011 | Tan et al., 2011 | Saravanan, 2011 | UNIDO , 2011 | Bond and Perrett, 2012 | Liu et al., 2012 | Na et al.,2012 | Liu et al., 2014 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 22 | Research, development, demonstration & dissemination | | | | | | | | | | √ | | | | | | | | | |
| 23 | Building maintenance organizations should consider environmental consciousness as a factor of competitiveness | | | | | | | | √ | | | | | | | | | | | |
| 24 | developing scientific, reasonable plan to make full use of energy and resource | | | | | | | | | | | | | | | | | | √ | |
| 25 | voluntary agreements (VAs). | | √ | | | | | | | | | | | | | | | | | |
| 26 | Employing energy management practices | | | | | | | | | | | | | | | √ | | | | |
| 27 | The development of tools to help in decision making | | | | | | | | √ | | | | | | | | | | | |
| 28 | developing the prevention and control measures for the pollution problems that maybe arise in the processes of construction | | | | | | | | | | | | | | | | | | √ | |
| 29 | Establish internal energy management institution with full-time energy management staffs | | | | | | | | | | | | | | | | | √ | | √ |
| 30 | Establish internal management regulations on energy saving and carbon mitigation | | | | | | | | | | | | | | | | | √ | | √ |

Table (C.5) : Collected best activities for energy saving "Continued"

| No. | Energy management activity | UNCHS, 1991 | Worrell and Price, 2001b | Plessis,2002 | Ibrik and Mahmoud, 2005 | UNEP, 2006 | Christoffersen et al., 2006 | Capehart et al. 2006 | Shafii et al., 2006 | Sengupta, 2008 | Akinbami and Lawal, 2009 | Xundi et al., 2010 | Chuanzhong and Yingji, 2011 | Tan et al., 2011 | Saravanan, 2011 | UNIDO , 2011 | Bond and Perrett, 2012 | Liu et al., 2012 | Na et al.,2012 | Liu et al., 2014 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 31 | New method and economic policy to close the gap between the increasing rate in energy consumption and economic development | | | | | | | | | | | √ | | | | | | | | |
| 32 | Sustainability policy and strategy are guidelines for implementing appropriate sustainable construction practice | | | | | | | | | | | | | √ | | | | | | |
| 33 | Sustainability policy within contractor organizations | | | | | | | | | | | | | √ | | | | | | |
| 34 | Energy policy | | | | | | √ | | | | | | | | | | | | | |
| 35 | Quantitative efficiency goals | | | | | | √ | | | | | | | | | | | | | |
| 36 | Set up targets for energy saving and GHG mitigation | | | | | | | | | | | | | | | | | | | √ |
| 37 | Information on Energy and greenhouse gas monitoring / targeting | | | | | √ | | | | | | | | | | | | | | |
| 38 | Action plan/goals | | | | | | √ | | | | | | | | | | | | | |
| 39 | Target Setting | | √ | | | | | | | | | | | | | | | | | |
| 40 | Commitment from top management about the goals to be achieved. | | | | | | | | | | | | | √ | | | | | | |
| 41 | Development of adequate energy database | | | | | | | | | | √ | | | | | | | | | |

Table (C.5) : Collected best activities for energy saving "Continued"

| No. | Energy management activity | UNCHS, 1991 | Worrell and Price, 2001b | Plessis,2002 | Ibrik and Mahmoud, 2005 | UNEP, 2006 | Christoffersen et al., 2006 | Capehart et al. 2006 | Shafii et al., 2006 | Sengupta, 2008 | Akinbami and Lawal, 2009 | Xundi et al., 2010 | Chuanzhong and Yingji, 2011 | Tan et al., 2011 | Saravanan, 2011 | UNIDO , 2011 | Bond and Perrett, 2012 | Liu et al., 2012 | Na et al.,2012 | Liu et al., 2014 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 42 | Mapping of energy use | | | | | | √ | | | | | | | | | | | | | |
| 43 | reporting and benchmarking energy consumption | | √ | | | | | | | | | | | | | | | | | |
| 44 | Energy audits to improve the existing industry systems with their equipment and units and increase efficiency | | | | √ | | | | | | | | | | | | | | | |
| 45 | diversified audits and power measurements for energy saving | | | | √ | | | | | | | | | | | | | | | |
| 46 | Conducting energy audits on typical construction sites to identify energy use and energy–saving opportunities | √ | | | | | | | | | | | | | | | | | | |
| 47 | Conduct energy auditing for understanding internal energy use situation and to identify potentials | | | | | | | | | | | | | | | | | √ | | √ |
| 48 | The supervision unit should track, review, regulate and inspect the progress and performance of the construction on behalf of the interests of owners, especially for the selection of green materials and the prevention for the pollution | | | | | | | | | | | | | | | | | | √ | |
| 49 | Looking for ways to reduce materials use by the use of closer supervision and quality control | √ | | | | | | | | | | | | | | | | | | |

Table (C.5) : Collected best activities for energy saving "Continued"

| No. | Energy management activity | UNCHS, 1991 | Worrell and Price, 2001b | Plessis,2002 | Ibrik and Mahmoud, 2005 | UNEP, 2006 | Christoffersen et al., 2006 | Capehart et al. 2006 | Shafii et al., 2006 | Sengupta, 2008 | Akinbami and Lawal, 2009 | Xundi et al., 2010 | Chuanzhong and Yingji, 2011 | Tan et al., 2011 | Saravanan, 2011 | UNIDO , 2011 | Bond and Perrett, 2012 | Liu et al., 2012 | Na et al.,2012 | Liu et al., 2014 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 50 | Developing and maintaining effective monitoring, reporting, and management strategies for wise energy usage | | | | | | | √ | | | | | | | | | | | | |
| 51 | Examining energy efficiency of all buildings used in the construction process | √ | | | | | | | | | | | | | | | | | | |
| 52 | Mandatory energy efficiency reporting | | | | | | | | | | | | | | | | √ | | | |
| 53 | Continuous energy accounting | | | | | | √ | | | | | | | | | | | | | |
| 54 | Energy accounting used to keep track of energy consumption and costs. | | | | | | | √ | | | | | | | | | | | | |
| 55 | Monitoring and Evaluation | | √ | | | | | | | | | | | | | | | | | |
| 56 | Software (for energy monitoring, benchmarking etc.) | | | | | √ | | | | | | | | | | | | | | |
| 57 | Developing interest in and dedication to the energy management program from all employees | | | | | | | √ | | | | | | | | | | | | |
| 58 | More attention from all the stakeholders being paid to saving energy | | | | | | | | | | | √ | | | | | | | | |
| 59 | The awareness of the need for energy saving | | | | | | | | | | √ | | | | | | | | | |
| 60 | Making site staff aware of the energy implications of all site activities | √ | | | | | | | | | | | | | | | | | | |

Table (C.5) : Collected best activities for energy saving "Continued"

| No. | Energy management activity | UNCHS, 1991 | Worrell and Price, 2001b | Plessis,2002 | Ibrik and Mahmoud, 2005 | UNEP, 2006 | Christoffersen et al., 2006 | Capehart et al. 2006 | Shafii et al., 2006 | Sengupta, 2008 | Akinbami and Lawal, 2009 | Xundi et al., 2010 | Chuanzhong and Yingji, 2011 | Tan et al., 2011 | Saravanan, 2011 | UNIDO , 2011 | Bond and Perrett, 2012 | Liu et al., 2012 | Na et al.,2012 | Liu et al., 2014 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 61 | Educating key employees | | | | | | √ | | | | | | | | | | | | | |
| 62 | Construction stockholders education | | | √ | | | | | | | | | | | | | | | | |
| 63 | Social dialogue and awareness raising related to sustainable construction and green jobs | | | | | | | | | | | | | | | | | | | |
| 64 | Better advertising | | | | | | | | | | | | | | | | √ | | | |
| 65 | Newsletters with energy developments | | | | | √ | | | | | | | | | | | | | | |
| 66 | Cultivating good communications on energy matters | | | | | | | √ | | | | | | | | | | | | |
| 67 | Make full use of media reports and films, television, cartoon etc. to propaganda low-carbon economy, energy-saving technology. | | | | | | | | | | | | √ | | | | | | | |
| 68 | Use available methods and techniques for awareness, like video films, radio and TV, local press, posters, communication and networking | | | | √ | | | | | | | | | | | | | | | |
| 69 | Awareness campaign/outreach program by seminars, conferences, workshops, radio/television talks programs. | | | | | | | | | | √ | | | | | | | | | |
| 70 | Energy education by means of introducing new courses for both conventional and renewable energy sources | | | | √ | | | | | | | | | | | | | | | |

Table (C.5) : Collected best activities for energy saving "Continued"

| No. | Energy management activity | UNCHS, 1991 | Worrell and Price, 2001b | Plessis,2002 | Ibrik and Mahmoud, 2005 | UNEP, 2006 | Christoffersen et al., 2006 | Capehart et al. 2006 | Shafii et al., 2006 | Sengupta, 2008 | Akinbami and Lawal, 2009 | Xundi et al., 2010 | Chuanzhong and Yingji, 2011 | Tan et al., 2011 | Saravanan, 2011 | UNIDO , 2011 | Bond and Perrett, 2012 | Liu et al., 2012 | Na et al.,2012 | Liu et al., 2014 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 71 | Arrange internal training of employees to raise their energy-saving awareness | | | | | | | | | | | | | | | | | √ | | √ |
| 72 | Education and training should incorporate sustainable development concepts | | | | | | | | √ | | | | | | | | | | | |
| 73 | Participate in energy-saving training and pilot projects arranged by national or local governments | | | | | | | | | | | | | | | | | √ | | √ |
| 74 | Conducting training events for builders in energy conservation | √ | | | | | | | | | | | | | | | | | | |
| 75 | Training / courses on energy efficient technologies | | | | | √ | | | | | | | | | | | | | | |
| 76 | Training / courses on Environmental / Energy management systems | | | | | √ | | | | | | | | | | | | | | |
| 77 | Training / courses on Financing CP / energy efficiency projects | | | | | √ | | | | | | | | | | | | | | |
| 78 | Training / courses on Kyoto Protocol / Clean Development Mechanism | | | | | √ | | | | | | | | | | | | | | |
| 79 | Training / courses on Energy efficient technologies | | | | | √ | | | | | | | | | | | | | | |
| 80 | Training / courses on Cleaner Production (CP) / Energy auditing | | | | | √ | | | | | | | | | | | | | | |

Table (C.5) : Collected best activities for energy saving "Continued"

| No. | Energy management activity | UNCHS, 1991 | Worrell and Price, 2001b | Plessis,2002 | Ibrik and Mahmoud, 2005 | UNEP, 2006 | Christoffersen et al., 2006 | Capehart et al. 2006 | Shafii et al., 2006 | Sengupta, 2008 | Akinbami and Lawal, 2009 | Xundi et al., 2010 | Chuanzhong and Yingji, 2011 | Tan et al., 2011 | Saravanan, 2011 | UNIDO , 2011 | Bond and Perrett, 2012 | Liu et al., 2012 | Na et al.,2012 | Liu et al., 2014 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 81 | Inform employees | | | | | | √ | | | | | | | | | | | | | |
| 82 | Information on Energy efficient technologies | | | | | √ | | | | | | | | | | | | | | |
| 83 | Information programs | | √ | | | | | | | | | | | | | | | | | |
| 84 | Information on Environmental / Energy management systems | | | | | √ | | | | | | | | | | | | | | |
| 85 | Information on Financing CP / energy efficiency projects | | | | | √ | | | | | | | | | | | | | | |
| 86 | Information on Energy monitoring instruments | | | | | √ | | | | | | | | | | | | | | |
| 87 | Information on Case studies of other companies | | | | | √ | | | | | | | | | | | | | | |
| 88 | Information on Government policies / legislation / $ incentives | | | | | √ | | | | | | | | | | | | | | |
| 89 | Information on Benchmarking data | | | | | √ | | | | | | | | | | | | | | |
| 90 | Information on Kyoto Protocol / Clean Development Mechanism | | | | | √ | | | | | | | | | | | | | | |
| 91 | Information on Cleaner Production (CP) / Energy auditing | | | | | √ | | | | | | | | | | | | | | |
| 92 | Directory with energy contacts (technology providers, energy experts, financers, government agencies etc.) | | | | | √ | | | | | | | | | | | | | | |

Table (C.5) : Collected best activities for energy saving "Continued"

| No. | Energy management activity | UNCHS, 1991 | Worrell and Price, 2001b | Plessis,2002 | Ibrik and Mahmoud, 2005 | UNEP, 2006 | Christoffersen et al., 2006 | Capehart et al. 2006 | Shafii et al., 2006 | Sengupta, 2008 | Akinbami and Lawal, 2009 | Xundi et al., 2010 | Chuanzhong and Yingji, 2011 | Tan et al., 2011 | Saravanan, 2011 | UNIDO , 2011 | Bond and Perrett, 2012 | Liu et al., 2012 | Na et al.,2012 | Liu et al., 2014 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 93 | Collect information on energy saving and carbon mitigation policies | | | | | | | | | | | | | | | | | √ | | √ |
| 94 | Understanding sustainability principles and legislation | | | | | | | | | | | | | √ | | | | | | |
| 95 | Motivate employees | | | | | | √ | | | | | | | | | | | | | |
| 96 | Introducing new methods, technologies and solutions for sustainable practices in Gaza construction industry | | | | | | | | | | | | | | | | | | | |
| 97 | Improved and innovative techniques of construction by reduction in quantity of building materials | | | | | | | | | √ | | | | | | | | | | |
| 98 | utilize new technology innovation | | | | | | | | | | | | √ | | | | | | | |
| 99 | Replacing old technologies | | | | | | | | | | | | | | | √ | | | | |
| 100 | Using new technology | | | | | | | | | | | √ | | | | | | | | |
| 101 | Adopting energy-saving technologies | | | | | | | | | | | | | | | √ | | | | |
| 102 | Improving processes and optimizing systems | | | | | | | | | | | | | | | √ | | | | |
| 103 | Innovating product designs | | | | | | | | | | | | | | | √ | | | | |
| 104 | Systematic energy-efficiency design | | | | | | √ | | | | | | | | | | | | | |
| 105 | Improvement of systems (air-conditioning, heating, water heating) | | | √ | | | | | | | | | | | | | | | | |

Table (C.5) : Collected best activities for energy saving "Continued"

| No. | Energy management activity | UNCHS, 1991 | Worrell and Price, 2001b | Plessis,2002 | Ibrik and Mahmoud, 2005 | UNEP, 2006 | Christoffersen et al., 2006 | Capehart et al. 2006 | Shafii et al., 2006 | Sengupta, 2008 | Akinbami and Lawal, 2009 | Xundi et al., 2010 | Chuanzhong and Yingji, 2011 | Tan et al., 2011 | Saravanan, 2011 | UNIDO , 2011 | Bond and Perrett, 2012 | Liu et al., 2012 | Na et al.,2012 | Liu et al., 2014 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 106 | Promote daily energy saving activities in offices: lighting, air-conditioning, etc | | | | | | | | | | | | | | | | | | | √ |
| 107 | Organize the employees to practice daily energy-saving activities in office (such as lighting, air-conditioner, etc.) | | | | | | | | | | | | | | | | | √ | | √ |
| 108 | Reducing journeys and utilizing the most energy−efficient means of transport available | √ | | | | | | | | | | | | | | | | | | |
| 109 | Discounted / free expert's advice | | | | | √ | | | | | | | | | | | | | | |
| 110 | Having invested in new production facilities to reduce energy use and carbon emissions | | | | | | | | | | | | | | | | | √ | | √ |
| 111 | Examining the energy efficiency of all mechanical plant used | √ | | | | | | | | | | | | | | | | | | |
| 112 | replacing inefficient plant with more efficient plant | √ | | | | | | | | | | | | | | | | | | |
| 113 | reducing the unnecessary use of plant | √ | | | | | | | | | | | | | | | | | | |
| 114 | Strengthen daily maintenance of production equipment to reduce energy use | √ | | | | | | | | | | | | | | | | √ | | √ |
| 115 | Install monitoring devices for major energy-consuming equipment for better statistics of internal energy use | | | | | √ | | | | | | | | | | | | √ | | √ |

Table (C.5) : Collected best activities for energy saving "Continued"

| No. | Energy management activity | UNCHS, 1991 | Worrell and Price, 2001b | Plessis,2002 | Ibrik and Mahmoud, 2005 | UNEP, 2006 | Christoffersen et al., 2006 | Capehart et al. 2006 | Shafii et al., 2006 | Sengupta, 2008 | Akinbami and Lawal, 2009 | Xundi et al., 2010 | Chuanzhong and Yingji, 2011 | Tan et al., 2011 | Saravanan, 2011 | UNIDO , 2011 | Bond and Perrett, 2012 | Liu et al., 2012 | Na et al.,2012 | Liu et al., 2014 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 116 | Utilization of building products and materials, which can be reused or recycled | | | | | | | | | | | | | | √ | | | | | |
| 117 | Utilization of nature, space and material saving construction methods | | | | | | | | | | | | | | √ | | | | | |
| 118 | Use of alternate low-energy consuming materials | | | | | | | | | √ | | | | | | | | | | |
| 119 | Reducing building material wastage | | | √ | | | | | | | | | | | | | | | | |
| 120 | Increasing the use of recycled waste as building materials | | | √ | | | | | | | | | | | | | | | | |
| 121 | Selecting where possible only local sources of materials supply | √ | | | | | | | | | | | | | | | | | | |
| 122 | Looking for opportunities to save wastage of materials | √ | | | | | | | | | | | | | | | | | | |
| 123 | Separating all waste materials generated to facilitate their recycling | √ | | | | | | | | | | | | | | | | | | |
| 124 | Optimize the transportation of raw materials and products to reduce energy use of logistics | | | | | | | | | | | | | | | | | √ | | √ |
| 125 | Use of alternative energy sources and passive solar design improvements | | | √ | | | | | | | | | | | | | | | | |

Table (C.5) : Collected best activities for energy saving "Continued"

| No. | Energy management activity | UNCHS, 1991 | Worrell and Price, 2001b | Plessis,2002 | Ibrik and Mahmoud, 2005 | UNEP, 2006 | Christoffersen et al., 2006 | Capehart et al. 2006 | Shafii et al., 2006 | Sengupta, 2008 | Akinbami and Lawal, 2009 | Xundi et al., 2010 | Chuanzhong and Yingji, 2011 | Tan et al., 2011 | Saravanan, 2011 | UNIDO , 2011 | Bond and Perrett, 2012 | Liu et al., 2012 | Na et al.,2012 | Liu et al., 2014 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 126 | Utilization of renewable energies for production, transport and performance | | | | | | | | | | | | | | √ | | | | | |
| 127 | Speed up the development of new energy sources such as renewable energy | | | | | | | | | | | | √ | | | | | | | |
| 128 | Adjust the structure of energy consumption by using cleaner energy | | | | | | | | | | | | | | | | | √ | | √ |
| 129 | Energy-efficient purchases | | | | | | √ | | | | | | | | | | | | | |

**Other resources for energy saving activities**

Worrell and Price,( 2001a); Eisenberg et al. (2002); Sustainability Victoria (2007); Al-Mofleh et al. (2009); Hwang and Tan (2010); Tanaka, Tan et al. (2011) Wai et al. (2011); Zhang et al. (2011); Apeaning (2012); Muhaisen and Ahlbäck (2012); Hee et al. (2014).

# Appendix (D)

# Results of experts revision for collected factors

Table (D.1) : Revision results for the collected energy management awareness features

| No | Energy management requirement | Process | Final factor |
|---|---|---|---|
| 1 | Onsite energy costs represent an important part of the project overall costs. | Selected | Onsite energy costs represent an important part of the project overall costs. |
| 2 | Increased onsite energy use may result in different negative environmental impacts. | Selected | Increased onsite energy use may result in different negative environmental impacts. |
| 3 | GHG emissions are the highest negative environmental impact associated with energy use during onsite construction. | Selected | GHG emissions are the highest negative environmental impact associated with energy use during onsite construction. |
| 4 | There is gap between knowledge and application of energy efficiency in local construction industry. | Modified | There is gap between knowledge and application of energy efficiency in local construction industry. |
| 5 | Energy management is one component of the sustainability concept. | Modified | Energy management is one component of the sustainability concept. |
| 6 | Energy management improves the company performance (competitive advantage). | Selected | Energy management improves the company performance (competitive advantage). |
| 7 | Application of energy management affects the project management method/style. | Selected | Application of energy management affects the project management method/style. |
| 8 | Energy management is one of the construction business ethics. | Selected | Energy management is one of the construction business ethics. |
| 9 | Energy management highly reduces overall project cost. | Selected | Energy management highly reduces overall project cost. |
| 10 | Energy management highly reduces the negative environmental impacts of the project. | Modified | Energy management highly reduces the negative environmental impacts of the project. |

Table (D.2) : Revision results for the collected energy management application requirement

| No. | Energy management requirement | Process | Final factor |
|---|---|---|---|
| 1 | Have an energy policy | Selected | Have an energy policy |
| 2 | Have an energy strategy | Merged | My company preparing an energy management plan for each project to save energy during project construction |
| 3 | Energy management plan | Merged | |
| 4 | Creation of an Energy Manual | Deleted | |
| 5 | Identification of key performance indicators, unique to the company | Modified | Existence of company performance indicators for energy saving and management |
| 6 | Having an official energy manager | Modified | The company having a person responsible for energy issues |
| 7 | Setting an energy saving target | Selected | Setting an energy saving target |
| 8 | Monitoring and analyzing energy use | Merged | Analyzing onsite energy uses |
| 9 | Analysis of energy historical data | Merged | |
| 10 | Assess future energy needs | Merged | |
| 11 | Energy audit and accounting | Selected | Energy audit and accounting |
| 12 | Having implemented energy efficiency projects | Modified | Onsite energy saving had implemented in previous projects |
| 13 | Staff training and engagement | Modified | Existence of onsite energy management training programs for the company staff |
| 14 | Periodic reporting of progress | Merged | Periodic evaluation of applied onsite energy management |
| 15 | Evaluate program effectiveness | Merged | |
| 16 | Planning | Modified | Planning for energy management is one of the construction planning activities |
| 17 | Assessing the compliance with legal obligations | Modified | Reviewing of local energy management legislations and compliance with it |
| 18 | Energy costs included as an element of the price analysis of construction activities | Added | Energy costs included as an element of the price analysis of construction activities |
| 19 | The company provides onsite advertisement techniques and recommendations related to energy issues | Added | The company provides onsite advertisement techniques and recommendations related to energy issues |
| 20 | The company has a stable system to reward and punish workers for energy-related issues | Added | The company has a stable system to reward and punish workers for energy-related issues |
| 21 | Onsite energy management procedures included in project work schedule and method statement | Added | Onsite energy management procedures included in project work schedule and method statement |
| 22 | Energy cost is one of the company criteria for participation in the tender | Added | Energy cost is one of the company criteria for participation in the tender |

Table (D.3) : Revision results for the collected energy management adoption drivers

| No. | Driver for Energy Management | Process | Final Driver |
|---|---|---|---|
| 1 | Rising energy costs | Merged | Increased energy prices |
| 2 | The introduction or increasing of fees on energy resources consumed | Merged | |
| 3 | Cost saving from improved energy management | Merged | Cost saving from adopted energy management techniques |
| 4 | Cost reductions resulting from lowered energy use | Merged | |
| 5 | Decrease in technology price levels | Selected | Decrease in technology price levels |
| 6 | Differentiate from competitors | Merged | Establish a competitive advantage |
| 7 | Energy management level of competitors | Merged | |
| 8 | Establish a competitive advantage | Selected | |
| 9 | Influence of industrial association of the same sector | Merged | |
| 10 | Expand to new markets | Deleted | |
| 11 | Improve company brand | Merged | Improved reputation / recognition |
| 12 | Improved reputation / recognition | Selected | |
| 13 | Green Image of Corporation | Merged | |
| 14 | Take care of environment | Merged | Existence of environmental management system in the company |
| 15 | Environmental company profile | Merged | |
| 16 | Environmental management system | Merged | |
| 17 | Improved working conditions | Selected | Improved working conditions |
| 18 | Improved staff pride / morale | Deleted | |
| 19 | People with real ambition | Selected | People with real ambition |
| 20 | Tenant satisfaction and productivity | Deleted | |
| 21 | Top manager’s support to energy saving activities | Selected | Top manager’s support to energy saving activities |
| 22 | Long-rang plans within sector | Merged | Long term energy management plans(strategies)in construction sector |
| 23 | Long term energy strategy | Merged | |
| 24 | Energy Efficient Scheme | Merged | |
| 25 | Strength of governmental requirements of energy saving | Selected | Strength of governmental requirements of energy saving |
| 26 | Information on practices (Having information on successfully-implemented practices) | Selected | Information on practices (Having information on successfully-implemented practices) |

Table (D.3) : Revision results for the collected energy management adoption drivers "Continued"

| No. | Driver for Energy Management | Process | Final Driver |
|---|---|---|---|
| 27 | Energy performance contracts | Selected | Energy performance contracts |
| 28 | Local Governmental regulations | Modified | Existence of local Governmental regulations related to energy issues |
| 29 | Governmental measures intended to drive Greenhouse Gas (GHG) (namely CO2) and energy consumption reduction | Merged | |
| 30 | Governmental policy | Merged | |
| 31 | Carbon taxation | Merged | Existence of Energy tax |
| 32 | Energy tax | Modified | |
| 33 | Emissions tax | Merged | |
| 34 | Awareness of internal energy use and problems | Selected | Awareness of internal energy use and problems |
| 35 | Increased education level of employees | Selected | Increased education level of employees |
| 36 | Frequency of internal training on energy saving | Selected | Frequency of internal training on energy saving |
| 37 | Greater availability of green products | Deleted | |
| 38 | Satisfy customers requirements | Modified | Satisfy client/donor requirements |
| 39 | Commitment to sustainability | Selected | Commitment to sustainability |
| 40 | Improved compliance with corporate environmental targets | Merged | Company willingness to reduce energy consumption |
| 41 | Willingness to improve energy efficiency | Merged | |
| 42 | Company's intention to invest in new facility for energy saving | Merged | |
| 43 | Industry rating system | Modified | Existence of rating system in construction system based on company energy management situation |
| 44 | Building code requirements | Selected | Building code requirements |
| 45 | Voluntary agreements with tax exception | Merged | Financial support for energy saving strategies/plans and investments |
| 47 | Special financing opportunities for investments | Merged | |
| 48 | Non-energy benefits (improved indoor environment, comfort, health, safety, and productivity , labor and time savings | Selected | Non-energy benefits (improved indoor environment, comfort, health, safety, and productivity , labor and time savings |
| 49 | Access to energy efficiency experts | Selected | Access to energy efficiency experts |

Table (D.3) : Revision results for the collected energy management adoption drivers "Continued"

| No. | Driver for Energy Management | Process | Final Driver |
|---|---|---|---|
| 50 | Clients (Having clients who are interested in energy efficiency and environmental issues) | Selected | Clients (Having clients who are interested in energy efficiency and environmental issues) |
| 51 | High energy management requirements in contract documents | Added | High energy management requirements in contract documents |
| 52 | Company energy performance is one of the contractor selection criteria | Added | Company energy performance is one of the contractor selection criteria |
| 53 | Type of project donor/client (Local, international) | Added | Type of project donor/client (Local, international) |
| 54 | Large project size and high amount of energy required | Added | Large project size and high amount of energy required |
| 55 | Availability of different energy types in local market | Added | Availability of different energy types in local market |
| 56 | Availability of energy saving products and tools | Added | Availability of energy saving products and tools |

Table (D.4) : Revision results for the collected energy management adoption barriers

| No. | Barriers for Energy Management | Process | Final barrier |
|---|---|---|---|
| 1 | Corporate culture | Deleted | |
| 2 | Our company / Companies' culture does not encourage staff to give suggestions for improvement | Modified | Company senior management doesn't provide support for energy saving activities |
| 3 | Our company / Companies do not have targets for energy (only for production) | Modified | Management finds production more important (not have energy targets) |
| 4 | Energy objectives not integrated into operating, maintenance or purchasing procedure | Merged | |
| 5 | Management finds production more important | Modified | |
| 6 | Energy only auxiliary function | Merged | Construction energy costs are not sufficiently important compared with other costs. |
| 7 | Energy costs are not sufficiently important | Modified | |
| 8 | Organizations lack 'long term' vision and are short term oriented | Modified | The company lacks long-term vision and it is short-term oriented. |
| 9 | Lack of Green Supply Chain Management practices in organizations vision | Deleted | |
| 10 | Lack of Green Supply Chain Management practices in organizations mission | Deleted | |
| 11 | Lack of strategy to promote sustainable construction | Merged | Lack of procedures or strategy to promote sustainable construction |
| 12 | There is a lack of policies, procedures and systems within our company / companies | Merged | |
| 13 | Lack of IT infrastructure systems like environmental monitoring system(EMS) in the organization | Deleted | |
| 14 | Lack of ethical standards and corporate social responsibility | Modified | The company lack of ethical standards and corporate social responsibility |
| 15 | lack of interest | Merged | Company management lack interest in onsite energy costs and consumption issues. |
| 16 | Lack of interest in the issue of sustainability | Merged | |
| 17 | Dep./Workers not accountable for energy costs | Merged | |
| 18 | Lack of importance of energy consumption in daily business | Merged | |

Table (D.4) : Revision results for the collected energy management adoption barriers

| No. | Barriers for Energy Management | Process | Final barrier |
|---|---|---|---|
| 19 | Feeling of 'too complex' to implement Green Supply Chain Management among stakeholders | Deleted | |
| 20 | Unwillingness to pay additional costs | Modified | Additional costs needed to improve the company energy efficiency. |
| 21 | Management is concerned about the investment costs of energy | Merged | |
| 22 | Low priority given to energy management | Deleted | |
| 23 | Lack of communication and interest among project team members | Deleted | |
| 24 | There is a lack of coordination between external organizations | Deleted | |
| 25 | Lack of cooperation within the supply chain stakeholders | Deleted | |
| 26 | There is a lack of coordination between departments within our company / companies | Deleted | |
| 27 | Other investments more important | Deleted | |
| 28 | Management believe there is no/little scope for improvement | Selected | Management believe that there is no/little scope for the company energy performance improvement . |
| 29 | Lack of support from senior management | Selected | Company senior management doesn't provide support for energy saving activities |
| 30 | Lack of leadership and commitment from senior and middle level managers | Merged | |
| 31 | lack of support by employees | Merged | |
| 32 | Lack of staff awareness | Merged | Lack of the company staff awareness on the importance of energy management during onsite construction. |
| 33 | Workers' unaware of the correct methods and procedures | Merged | |
| 34 | Lack of Awareness on sustainable building | Merged | |
| 35 | There is a lack of awareness of the importance of energy efficiency | Merged | |
| 36 | Regional ambiguities in the green concept | Deleted | |
| 37 | Lack of Public awareness | Deleted | |
| 38 | Lack of owner/occupier awareness | Modified | |
| 39 | Lack of developer awareness | Merged | |

Table (D.4) : Revision results for the collected energy management adoption barriers

| No. | Barriers for Energy Management | Process | Final barrier |
|---|---|---|---|
| 40 | Lack of information | Merged | Difficulties to access technical information and expertise related to energy management in construction. |
| 41 | Poor access to information | Merged | |
| 42 | It is difficult to access external technical information and expertise | Merged | |
| 43 | Lack of accurate data | Merged | |
| 44 | Poor information quality regarding energy efficiency opportunities | Merged | |
| 45 | Difficulties in obtaining information about energy consumption of purchased equipment's | Merged | |
| 46 | Lack of Design and Construction team | Deleted | |
| 47 | There is no specific person or committee dealing with energy at companies | Modified | No specific person or committee assigned to deal with onsite energy issues. |
| 48 | Sufficient lack of green architects, consultants, green developers, contractors in the region | Deleted | |
| 66 | Technology will become cheaper | Deleted | |
| 67 | May be new technology will not satisfy future standards | Deleted | |
| 68 | Misunderstanding of green technological operations | Deleted | |
| 69 | Restrictions of new green production and technology | Deleted | |
| 70 | Limited availability of green suppliers and information | Deleted | |
| 49 | Lack of technical skills | Modified | Lack of technical skills\knowledge on construction energy management technologies. |
| 50 | Lack of professional knowledge | Merged | |
| 51 | Lack of Professional capabilities/Designers | Merged | |
| 52 | Lack of knowledge on green technology and materials | Merged | |
| 54 | Lack of Expertise | Merged | |
| 55 | Lack of experience among the stakeholders in executing Green Supply Chain Management | Merged | |
| 56 | No good overview of existing technologies | Deleted | |

Table (D.4) : Revision results for the collected energy management adoption barriers “Continues”

| No. | Barriers for Energy Management | Process | Final barrier |
|---|---|---|---|
| 57 | Resistance to change from their traditional practices | Selected | Resistance to change from traditional practices to more energy efficient practices. |
| 58 | Technological inertia | Merged | Lack of innovative energy technologies/equipment in local market |
| 59 | Technical obstructions | Merged | |
| 60 | Lack of innovative technology in manufacturing and construction | Modified | |
| 61 | Limited availability of new technology | Merged | |
| 62 | Lack of technology for waste management and recycling | Merged | |
| 63 | Imperfect green technological specifications | Merged | |
| 64 | Unreliable /Unproven technology | Merged | |
| 65 | Technology is inappropriate at this site | Merged | |
| 71 | Availability of green material and equipment | Deleted | |
| 72 | Uncertainty with green material and equipment | Deleted | |
| 73 | High cost in green material and equipment | Deleted | |
| 77 | Uncertain economic environment | Selected | Uncertain local economic environment. |
| 78 | Economic environment | Merged | |
| 79 | International crisis and economic down turn | Merged | |
| 74 | Lack of training | Merged | |
| 75 | Lack of Training and Education in Sustainable Design and Construction | Selected | |
| 76 | Lack of training in Green Supply Chain Management | Merged | |
| 80 | The Government does not give financial incentives to become energy efficient | Merged | |
| 81 | Lack of Government support | Selected | |
| 82 | Lack of preferential treatment and long term contracts for adopting Green Supply Chain Management from government | Merged | |
| 83 | Lack of government incentives and best practices awards for adopting Green Supply Chain Management | Merged | |
| 84 | lack of environmental incentive | Merged | |
| 85 | Lack of incentives | Merged | |
| 86 | Lack of incentive and motivation | Merged | |

Table (D.4) : Revision results for the collected energy management adoption barriers “Continues”

| No. | Barriers for Energy Management | Process | Final barrier |
|---|---|---|---|
| 87 | High initial investment in implementing Green Supply Chain Management | Merged | High costs of energy management options (measures/technologies).) |
| 88 | Higher investment cost | Merged | |
| 89 | The high cost of proposed measures | Merged | |
| 90 | Only new expensive technologies will improve energy efficiency at companies | Merged | |
| 91 | Higher final cost | Merged | |
| 92 | The higher cost of sustainable building Option | Merged | |
| 93 | Additional costs caused by green construction | Merged | |
| 94 | Cost of identifying opportunities, analyzing cost effectiveness and tendering | Merged | |
| 95 | Measure costs exceed willingness to pay | Merged | |
| 96 | Cost of staff replacement, retirement, retraining | Merged | |
| 97 | Current installations are sufficiently efficient | Deleted | |
| 98 | Short payback time | Merged | |
| 99 | Slow return on Investments(ROI) after implementing Green Supply Chain Management | Merged | |
| 100 | High cost Vs. perceived benefits | Merged | |
| 101 | Low profit margins | Selected | |
| 102 | Lack of budget funding | Selected | |
| 103 | It is difficult to obtain financing for energy efficiency projects | Merged | |
| 104 | Better to wait for subsidies | Merged | |
| 105 | Internal constraints on budget | Merged | |
| 106 | Access to capital | Merged | |
| 107 | High competition in the construction sector | Selected | |
| 108 | Conflicts in benefits with competitors | Deleted | |
| 109 | Risk of investment | Deleted | |
| 110 | Unforeseen circumstances in green project | Deleted | |
| 111 | Market uncertainty due to project delay, project on hold and cancellation | Deleted | |
| 112 | Uncertainty in the performance of green materials and equipment | Deleted | |

Table (D.4) : Revision results for the collected energy management adoption barriers "Continues"

| No. | Barriers for Energy Management | Process | Final barrier |
|---|---|---|---|
| 113 | Uncertainty regarding the quality | Deleted | |
| 114 | Possible poor performance of equipment | Deleted | |
| 115 | Technical risks such as risk of production disruptions | Selected | |
| 116 | Lack of customer demands for sustainable projects | Merged | Law client/donor demand |
| 117 | Lack of Demand | Merged | |
| 118 | Law client demand | Modified | |
| 119 | Energy is cheap | Deleted | |
| 120 | Energy costs not transparent | Deleted | |
| 121 | Inappropriate energy pricing | Deleted | |
| 122 | Energy supply constraint | Deleted | |
| 124 | Lack of time | Merged | |
| 125 | Management is concerned about time required to improve energy efficiency | Merged | |
| 126 | More time is required to implement green construction practices onsite | Merged | |
| 127 | Lengthy approval process for new green technologies within the organization | Merged | |
| 128 | The process to obtain approval from top management for investments is long | Merged | |
| 129 | Long decision chains | Merged | |
| 130 | Client uses a lot of time in making decision | Merged | |
| 131 | Green consultant delay in providing information | Merged | |
| 132 | Government policy | Deleted | Lack of governmental legislations for environment protection and energy conservation in construction sector. |
| 133 | Regulatory barriers | Merged | |
| 134 | Lack of legislation | Selected | |
| 135 | Environmental policies and legislation relating to energy are weak | Merged | |
| 136 | Authorities are not strict in enforcing environmental regulations | Merged | |
| 137 | Lack of Building Codes and Regulation | Modified | Lack of energy management codes and regulation in construction. |
| 138 | Lack of sustainability certifications like IS0 14001 | Deleted | |

Table (D.4) : Revision results for the collected energy management adoption barriers “Continues”

| No. | Barriers for Energy Management | Process | Final barrier |
|---|---|---|---|
| 139 | Lack of a measurement tool | Merged | Lack of audit and quantitative evaluation tools for company energy performance |
| 140 | Lack of quantitative evaluation tools for green performance | Modified | |
| 141 | Benefits of implemented energy efficiency measures are not quantifiable | Merged | |
| 142 | Lack of internal sustainability audits within the organization | Merged | |
| 143 | Lack of external sustainability audits of suppliers and contractors | Merged | |
| 144 | Conflict of interest between consultant and project manager | Merged | Conflicts of interest within the project members (owner/consultant/contractor). |
| 145 | Conflicts of interest within the company | Merged | |
| 146 | Conflict with the architect over the type of material to be used | Merged | |
| 147 | Lack of integrated research | | |
| 148 | Reduction of structure aesthetic | Deleted | |
| 149 | Dependence on promotion by government | Deleted | |
| 150 | Lack of demonstration examples | Selected | Lack of demonstration examples on energy management in construction industry |
| 151 | Better to await experience of colleagues | Merged | |
| 152 | lack of capacity of the construction sector | Deleted | |
| 153 | Hassles of implementing efficiency projects | Deleted | |
| 154 | Slim Organization | Deleted | |
| 155 | Energy managers lacks influence | Deleted | |
| 156 | Increased Documentation | Deleted | |
| 157 | Difficulty in comprehending the green specifications in the contract details | Modified | The contract documents do not impose any special conditions/specifications for energy management |
| 158 | Difficulty in the selection of subcontractors in providing green construction service | Deleted | |
| 159 | Extensive Pre-contract planning | Deleted | |
| 123 | Incremental time caused by green construction | Merged | Management is concerned about the time required to adopt energy management practices |
| 160 | Lengthy planning and approval process for new green technologies and materials | Modified | Tight project duration makes the management concerned about the time required to adopt energy management practices. |

Table (D.5) : Revision results for the collected best activity for energy saving

| No. | Activity | Process | Final activity |
|---|---|---|---|
| 1 | Legislative and regulatory support | Merged | |
| 2 | Energy regulations for energy consumption and direct/ indirect electrical loads | Merged | Applying the governmental regulations requirements related to construction energy use. |
| 3 | Change in legislation | Merged | |
| 4 | Government should advocate energy saving and low-carbon lifestyle by flexible economic incentive mechanism | Deleted | |
| 5 | Governments promote perfect incentive mechanisms for energy-saving including taxation relief, duty privilege, financial subsidies | Deleted | |
| 6 | Government should take effective measures to encourage enterprises that belong to high-carbon industry to raise their energy-saving efficiency fundamentally by scientific and technological innovation. | Modified | Adopting of the governmental fiscal measures related to onsite construction energy issues. |
| 7 | developing the prevention and control measures for the pollution problems that maybe arise in the processes of construction | Merged | |
| 8 | Apply for energy-saving subsidies at national or local level | Deleted | |
| 9 | Loans / subsidies for energy efficiency | Deleted | |
| 10 | Introducing incentives for energy saving | Deleted | |
| 11 | More rebates/subsidies | Deleted | |
| 12 | subsidies and tax credits | Deleted | |
| 13 | Providing incentives | Deleted | |
| 14 | Governmental Support for research into energy consumption in the construction process | Deleted | |
| 15 | Finding new and better ways to increase returns from energy investments through research and development | Deleted | |
| 16 | Research, development, demonstration and dissemination | Deleted | |

Table (D.5) : Revision results for the collected best activity for energy saving “Continued”

| No. | Activity | Process | Final activity |
|---|---|---|---|
| 17 | Optimizing and upgrading industry structure to raise energy-saving efficiency | Deleted | |
| 18 | Building owners and clients should play important roles in disseminating sustainable construction | Deleted | |
| 20 | The development of an energy code | Deleted | Adopting of the available energy code requirements for construction industry. |
| 21 | Building code change | Deleted | |
| 22 | Building certification | Deleted | |
| 23 | Building maintenance organizations should consider environmental consciousness as a factor of competitiveness | Deleted | |
| 24 | Developing scientific, reasonable plan to make full use of energy and resource | Selected | Developing scientific, reasonable energy action plan for the project to make full use of onsite energy and resources. |
| 25 | Voluntary agreements (VAs). | Selected | Participating in environmental friendly projects as possible. |
| 26 | Employing energy management practices | Merged | Adoption of more energy efficient construction methods as opposed to traditional construction methods during construction phase. |
| 19 | Improvement of the building construction process as opposed to the traditional methods | Merged | |
| 27 | The development of tools to help in decision making | Deleted | |
| 28 | Establish internal energy management institution with full-time energy management staffs | Modified | Employing a specialized team or person responsible for all energy issues during onsite works. |
| 29 | Establish internal management regulations on energy saving and carbon mitigation | Deleted | |
| 30 | New method and economic policy to close the gap between the increasing rate in energy consumption and economic development | Deleted | |
| 31 | Sustainability policy and strategy are guidelines for implementing appropriate sustainable construction practice | Deleted | |
| 32 | Sustainability policy within contractor organizations | Deleted | |

Table (D.5) : Revision results for the collected best activity for energy saving “Continued”

| No. | Activity | Process | Final activity |
|---|---|---|---|
| 33 | Energy policy | Deleted | |
| 34 | Quantitative efficiency goals | Merged | |
| 35 | Set up targets for energy saving and GHG mitigation | Modified | |
| 36 | Information on Energy and greenhouse gas monitoring / targeting | Merged | Setting a quantitative targets for onsite energy use and saving in each activity of the project. |
| 37 | Action plan/goals | Merged | |
| 38 | Target Setting | Merged | |
| 39 | Commitment from top management about the goals to be achieved. | Deleted | |
| 40 | Development of adequate energy database | Selected | |
| 41 | Mapping of energy use | Merged | Development of adequate energy database for the company projects. |
| 42 | Reporting and benchmarking energy consumption | Merged | |
| 43 | Energy audits to improve the existing industry systems with their equipment and units and increase efficiency | Merged | |
| 44 | Diversified audits and power measurements for energy saving | Merged | Conducting energy audits on the construction site to identify energy use and energy saving opportunities. |
| 45 | Conducting energy audits on typical construction sites to identify energy use and energy−saving opportunities | Selected | |
| 46 | Conduct energy auditing for understanding internal energy use situation and to identify potentials | Merged | |
| 47 | The supervision unit should track, review, regulate and inspect the progress and performance of the construction on behalf of the interests of owners, especially for the selection of green materials and the prevention for the pollution | Merged | |
| 48 | Looking for ways to reduce materials use by the use of closer supervision and quality control | Merged | Closer onsite supervision and quality control on energy issues. |
| 49 | Developing and maintaining effective monitoring, reporting, and management strategies for wise energy usage | Merged | |

Table (D.5) : Revision results for the collected best activity for energy saving “Continued”

| No. | Activity | Process | Final activity |
|---|---|---|---|
| 50 | Examining energy efficiency of all buildings used in the construction process | Deleted | |
| 51 | Mandatory energy efficiency reporting | Modified | Detailed reporting of the company onsite energy activities. |
| 52 | Continuous energy accounting | Deleted | Systematic review and analysis for the energy consumption of onsite activities and equipment. |
| 53 | Energy accounting used to keep track of energy consumption and costs. | Modified | |
| 54 | Monitoring and Evaluation | Merged | Software development for onsite energy monitoring and evaluation. |
| 55 | Software (for energy monitoring, benchmarking etc.) | Merged | |
| 56 | Developing interest in and dedication to the energy management program from all employees | Merged | Motivate the company employees to apply more onsite energy saving practices. |
| 57 | More attention from all the stakeholders being paid to saving energy | Merged | |
| 58 | The awareness of the need for energy saving | Merged | |
| 59 | Making site staff aware of the energy implications of all site activities | Selected | Motivate employees to adopt more energy saving practices |
| 60 | Educating key employees | Merged | |
| 95 | Motivate employees | Modefied | |
| 61 | Construction stockholders education | Merged | |
| 62 | Social dialogue and awareness raising related to sustainable construction and green jobs | Deleted | |
| 63 | Industry networks | Merged | Establishing good onsite communications between project staff about energy matters during construction phase. |
| 64 | Cultivating good communications on energy matters | Modified | |
| 65 | Better advertising | Merged | Using onsite energy manual (detailed work instructions) to save energy during onsite construction. |
| 66 | Newsletters with energy developments | Merged | |
| 67 | Make full use of media reports and films, television, cartoon etc to propaganda low-carbon economy, energy-saving technology. | Merged | |
| 68 | Use available methods and techniques for awareness, like video films, radio and TV, local press, posters, | Merged | |

Table (D.5) : Revision results for the collected best activity for energy saving "Continued"

| No. | Activity | Process | Final activity |
|---|---|---|---|
| 69 | Awareness campaign/outreach program by seminars, conferences, workshops, radio/television talks programs. | Merged | |
| 70 | Energy education by means of introducing new courses for both conventional and renewable energy sources | Merged | |
| 71 | Arrange internal training of employees to raise their energy-saving awareness | Merged | |
| 72 | Education and training should incorporate sustainable development concepts | Merged | |
| 73 | Participate in energy-saving training and pilot projects arranged by national or local governments | Merged | |
| 74 | Conducting training events for builders in energy conservation | Modefied | Conducting periodic meetings and training programs for the contractors staff in energy conservation systems/technologies. |
| 75 | Training / courses onEnergy efficient technologies | Merged | |
| 76 | Training / courses on Environmental / Energy management systems | Merged | |
| 77 | Training / courses on Financing CP / energy efficiency projects | Merged | |
| 78 | Training / courses on Kyoto Protocol / Clean Development Mechanism | Merged | |
| 79 | Training / courses on Energy efficient technologies | Merged | |
| 80 | Training / courses on Cleaner Production (CP) / Energy auditing | Merged | |
| 81 | Inform employees | Merged | |
| 93 | Directory with energy contacts (technology providers, energy experts, financers, government agencies etc.) | Deleted | |
| 94 | Understanding sustainability principles and legislation | Deleted | |
| 82 | Collect information on energy saving and carbon mitigation policies | Merged | |
| 83 | Information on Energy efficient technologies | Merged | Collect information on available energy saving systems, technologies and policies in local construction sector. |
| 84 | Information programs | Merged | |

Table (D.5) : Revision results for the collected best activity for energy saving "Continued"

| No. | Activity | Process | Final activity |
|---|---|---|---|
| 85 | Information on Environmental / Energy management systems | Merged | |
| 86 | Information on Financing CP / energy efficiency projects | Merged | |
| 87 | Information on Energy monitoring instruments | Merged | |
| 88 | Information on Case studies of other companies | Merged | |
| 89 | Information on Government policies / legislation / $ incentives | Merged | |
| 90 | Information on Benchmarking data | Merged | |
| 91 | Information on Kyoto Protocol / Clean Development Mechanism | Merged | |
| 92 | Information on Cleaner Production (CP) / Energy auditing | Merged | |
| 96 | Introducing new methods, technologies and solutions for sustainable practices in Gaza construction industry | Merged | |
| 97 | Improved and innovative techniques of construction by reduction in quantity of building materials | Merged | |
| 98 | utilize new technology innovation | Merged | Adopting energy-saving technologies and solutions during onsite construction |
| 99 | Replacing old technologies | Merged | |
| 100 | Using new technology | Merged | |
| 101 | Adopting energy-saving technologies | Selected | |
| 102 | Improving processes and optimizing systems | Merged | |
| 103 | Innovating product designs | Deleted | |
| 104 | Systematic energy-efficiency design | Deleted | |
| 105 | Improvement of systems (air-conditioning, heating, water heating) | Deleted | |
| 106 | Promote daily energy saving activities in offices: lighting,air-conditioning, etc | Deleted | |
| 107 | Organize the employees to practice daily energy-saving activities in office (such as lighting, air-conditioner, etc.) | Deleted | |

Table (D.5) : Revision results for the collected best activity for energy saving "Continued"

| No. | Activity | Process | Final activity |
|---|---|---|---|
| 108 | Discounted / free expert's advice | Deleted | Energy experts advices and recommendations |
| 109 | Having invested in new production facilities to reduce energy use and carbon emissions | Deleted | |
| 110 | Replacing inefficient plant with more efficient plant | Selected | Replacement of high energy consuming equipment with lower energy consuming equipment. |
| 111 | Reducing the unnecessary use of plant | Modified | Reducing the unnecessary use of energy consuming equipment and machines used during onsite construction. |
| 112 | Strengthen daily maintenance of production equipment to reduce energy use | Selected | |
| 113 | Install monitoring devices for major energy-consuming equipment for better statistics of internal energy use | Deleted | |
| 114 | Examining the energy efficiency of all mechanical plant used | Modified | Frequent examination of the energy efficiency of all equipment used on construction site. |
| 115 | Utilization of nature, space and material saving construction methods | Selected | Practicing of onsite construction methods leading to lower material use . |
| 116 | Use of alternate low-energy consuming materials | Deleted | |
| 117 | Reducing building material wastage | Selected | Reducing excessive material and wastage during onsite construction. |
| 118 | Looking for opportunities to save wastage of materials | Merged | |
| 119 | Increasing the use of recycled waste as building materials | Modefied | Increasing the use of recycled building materials |
| 120 | Utilization of building products and materials, which can be reused or recycled | Merged | |
| 121 | Selecting where possible only local sources of materials supply | Selected | Selecting where possible only local sources of materials supply |
| 122 | Separating all waste materials generated to facilitate their recycling | Deleted | |
| 123 | Optimize the transportation of raw materials and products to reduce energy use of logistics | Merged | Optimization of the transportation of raw materials and equipment to and within the site. |

Table (D.5) : Revision results for the collected best activity for energy saving "Continued"

| No. | Activity | Process | Final activity |
|---|---|---|---|
| 124 | Examining the extent of use of transport of materials etc. to and within the site, | Merged | |
| 125 | Reducing journeys and utilising the most energy–efficient means of transport available | Merged | |
| 126 | Use of alternative energy sources and passive solar design improvements | Merged | |
| 127 | Utilization of renewable energies for production, transport and performance | Selected | Utilization of renewable energies and green technologies for onsite production, transport and performance. |
| 128 | Speed up the development of new energy sources such as renewable enrgy | Merged | |
| 129 | Adjust the structure of energy consumption by using cleaner energy | Merged | |
| 130 | Using more high-quality energy, such as gas and electricity | Deleted | |
| 131 | Energy-efficient purchases | Deleted | |
| 132 | Industry decision makers should identify performance standards for the equipment used onsite | Added | Identification and revision of the performance standards for the equipment used onsite . |
| 133 | Energy efficiency should be considered as one criteria in contractor classification in PCU | Added | Selecting subcontractors who are experienced in energy issues and management in construction . |

# Appendix (E)

# Factor analysis results

➢ **Results of the final run of the factor analysis for energy management adoption drivers**

Table (E.1): Correlation matrix for energy management adoption drivers “Final run”

| | DEM1 | DEM2 | DEM3 | DEM4 | DEM6 | DEM7 | DEM9 | DEM10 | DEM11 | DEM13 | DEM15 | DEM17 | DEM18 | DEM19 | DEM20 | DEM21 | DEM22 | DEM24 | DEM26 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DEM1 | 1.00 | | | | | | | | | | | | | | | | | | |
| DEM2 | 0.58 | 1.00 | | | | | | | | | | | | | | | | | |
| DEM3 | 0.41 | 0.64 | 1.00 | | | | | | | | | | | | | | | | |
| DEM4 | 0.16 | 0.15 | 0.14 | 1.00 | | | | | | | | | | | | | | | |
| DEM6 | 0.02 | 0.06 | -0.03 | 0.12 | 1.00 | | | | | | | | | | | | | | |
| DEM7 | -0.09 | -0.04 | -0.09 | 0.14 | 0.66 | 1.00 | | | | | | | | | | | | | |
| DEM9 | -0.11 | -0.16 | -0.13 | 0.03 | 0.73 | 0.47 | 1.00 | | | | | | | | | | | | |
| DEM10 | 0.59 | 0.54 | 0.55 | 0.24 | -0.01 | -0.07 | -0.03 | 1.00 | | | | | | | | | | | |
| DEM11 | -0.07 | -0.11 | -0.05 | 0.10 | -0.18 | -0.17 | -0.06 | 0.09 | 1.00 | | | | | | | | | | |
| DEM13 | -0.05 | -0.13 | -0.14 | -0.02 | -0.17 | -0.08 | 0.02 | 0.05 | 0.42 | 1.00 | | | | | | | | | |
| DEM15 | -0.13 | -0.08 | -0.17 | 0.06 | 0.45 | 0.55 | 0.46 | -0.13 | 0.01 | 0.07 | 1.00 | | | | | | | | |
| DEM17 | 0.21 | 0.18 | 0.09 | 0.44 | 0.12 | 0.26 | 0.04 | 0.20 | -0.09 | -0.22 | 0.03 | 1.00 | | | | | | | |
| DEM18 | 0.14 | 0.21 | 0.19 | 0.48 | 0.28 | 0.13 | 0.13 | 0.14 | 0.04 | -0.24 | 0.00 | 0.47 | 1.00 | | | | | | |
| DEM19 | 0.20 | 0.18 | 0.09 | 0.60 | 0.09 | 0.14 | -0.07 | 0.16 | -0.05 | -0.20 | 0.04 | 0.63 | 0.51 | 1.00 | | | | | |
| DEM20 | 0.26 | 0.05 | 0.09 | 0.43 | -0.02 | -0.03 | 0.02 | 0.12 | 0.04 | -0.04 | 0.00 | 0.39 | 0.52 | 0.63 | 1.00 | | | | |
| DEM21 | 0.17 | 0.09 | -0.10 | 0.55 | 0.10 | 0.14 | 0.03 | 0.14 | -0.01 | -0.21 | 0.01 | 0.42 | 0.39 | 0.66 | 0.42 | 1.00 | | | |
| DEM22 | 0.29 | 0.15 | 0.14 | 0.51 | 0.15 | 0.27 | 0.11 | 0.29 | -0.07 | -0.19 | 0.06 | 0.76 | 0.48 | 0.73 | 0.53 | 0.52 | 1.00 | | |
| DEM24 | -0.02 | 0.03 | 0.00 | 0.00 | -0.05 | -0.04 | -0.06 | 0.00 | 0.48 | 0.44 | -0.04 | -0.10 | -0.10 | -0.14 | -0.13 | 0.03 | -0.11 | 1.00 | |
| DEM26 | 0.00 | -0.07 | -0.05 | 0.53 | 0.20 | 0.20 | 0.16 | -0.01 | 0.03 | -0.04 | 0.19 | 0.39 | 0.45 | 0.68 | 0.46 | 0.56 | 0.57 | -0.07 | 1.00 |

Table (E.2): Anti-image correlation matrix for energy management adoption drivers “Final run”

| | DEM1 | DEM2 | DEM3 | DEM4 | DEM6 | DEM7 | DEM9 | DEM10 | DEM11 | DEM13 | DEM15 | DEM17 | DEM18 | DEM19 | DEM20 | DEM21 | DEM22 | DEM24 | DEM26 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DEM1 | 0.69[a] | | | | | | | | | | | | | | | | | | |
| DEM2 | -0.36 | 0.67[a] | | | | | | | | | | | | | | | | | |
| DEM3 | 0.08 | -0.46 | 0.61[a] | | | | | | | | | | | | | | | | |
| DEM4 | 0.04 | 0.05 | -0.13 | 0.91[a] | | | | | | | | | | | | | | | |
| DEM6 | -0.21 | -0.09 | 0.10 | -0.05 | 0.56[a] | | | | | | | | | | | | | | |
| DEM7 | 0.14 | 0.07 | -0.08 | -0.02 | -0.51 | 0.67[a] | | | | | | | | | | | | | |
| DEM9 | 0.18 | 0.12 | -0.03 | 0.07 | -0.68 | 0.18 | 0.56[a] | | | | | | | | | | | | |
| DEM10 | -0.34 | -0.13 | -0.36 | -0.09 | 0.02 | 0.05 | -0.12 | 0.69[a] | | | | | | | | | | | |
| DEM11 | 0.05 | 0.15 | 0.04 | -0.08 | 0.10 | 0.11 | -0.01 | -0.20 | 0.59[a] | | | | | | | | | | |
| DEM13 | -0.03 | -0.04 | 0.26 | -0.16 | 0.22 | -0.11 | -0.16 | -0.22 | -0.14 | 0.53[a] | | | | | | | | | |
| DEM15 | 0.02 | -0.16 | 0.12 | -0.03 | 0.03 | -0.41 | -0.21 | 0.05 | -0.15 | -0.02 | 0.71[a] | | | | | | | | |
| DEM17 | -0.02 | -0.06 | 0.12 | -0.06 | 0.16 | -0.17 | -0.08 | 0.00 | 0.05 | 0.06 | 0.04 | 0.82[a] | | | | | | | |
| DEM18 | 0.17 | -0.17 | -0.06 | -0.16 | -0.30 | 0.11 | 0.08 | 0.04 | -0.19 | 0.14 | 0.13 | -0.22 | 0.79[a] | | | | | | |
| DEM19 | 0.18 | -0.20 | 0.02 | -0.12 | -0.23 | 0.11 | 0.34 | 0.03 | -0.02 | -0.01 | -0.04 | -0.23 | 0.11 | 0.80[a] | | | | | |
| DEM20 | -0.32 | 0.21 | -0.12 | 0.00 | 0.20 | 0.06 | -0.19 | 0.15 | 0.00 | -0.15 | -0.07 | 0.12 | -0.37 | -0.37 | 0.75[a] | | | | |
| DEM21 | -0.08 | -0.09 | 0.38 | -0.26 | 0.18 | -0.13 | -0.14 | -0.19 | 0.07 | 0.34 | 0.11 | 0.09 | -0.04 | -0.30 | -0.03 | 0.74[a] | | | |
| DEM22 | -0.17 | 0.14 | -0.04 | 0.00 | 0.16 | -0.20 | -0.16 | -0.18 | 0.03 | 0.11 | 0.06 | -0.49 | -0.02 | -0.26 | -0.09 | 0.04 | 0.84[a] | | |
| DEM24 | 0.01 | -0.10 | -0.14 | 0.05 | -0.16 | 0.01 | 0.11 | 0.22 | -0.42 | -0.40 | 0.09 | -0.06 | 0.07 | 0.14 | 0.09 | -0.30 | -0.07 | 0.46[a] | |
| DEM26 | 0.03 | 0.17 | -0.13 | -0.11 | -0.05 | 0.08 | -0.06 | 0.16 | -0.01 | -0.19 | -0.14 | 0.17 | -0.14 | -0.33 | 0.08 | -0.21 | -0.22 | 0.07 | 0.84[a] |

a. Measures of Sampling Adequacy(MSA)

Table (E.3): Total variance explained by factor analysis for the final run of the drivers for energy management adoption

| Component | Initial Eigenvalues | | | Extraction Sums of Squared Loadings | | | Rotation Sums of Squared Loadings | | |
|---|---|---|---|---|---|---|---|---|---|
| | Total | % of Variance | Cumulative % | Total | % of Variance | Cumulative % | Total | % of Variance | Cumulative % |
| 1 | 5.15 | 27.12 | 27.12 | 5.15 | 27.12 | 27.12 | 4.74 | 24.96 | 24.96 |
| 2 | 3.03 | 15.94 | 43.07 | 3.03 | 15.94 | 43.07 | 2.77 | 14.59 | 39.55 |
| 3 | 2.19 | 11.55 | 54.62 | 2.19 | 11.55 | 54.62 | 2.73 | 14.38 | 53.93 |
| 4 | 1.86 | 9.80 | 64.42 | 1.86 | 9.80 | 64.42 | 1.99 | 10.49 | 64.42 |
| 5 | 0.87 | 4.57 | 68.99 | | | | | | |
| 6 | 0.84 | 4.40 | 73.39 | | | | | | |
| 7 | 0.72 | 3.80 | 77.19 | | | | | | |
| 8 | 0.70 | 3.67 | 80.85 | | | | | | |
| 9 | 0.61 | 3.19 | 84.05 | | | | | | |
| 10 | 0.55 | 2.90 | 86.95 | | | | | | |
| 11 | 0.47 | 2.47 | 89.42 | | | | | | |
| 12 | 0.39 | 2.03 | 91.45 | | | | | | |
| 13 | 0.35 | 1.87 | 93.32 | | | | | | |
| 14 | 0.33 | 1.75 | 95.06 | | | | | | |
| 15 | 0.28 | 1.49 | 96.55 | | | | | | |
| 16 | 0.22 | 1.13 | 97.69 | | | | | | |
| 17 | 0.18 | 0.93 | 98.61 | | | | | | |
| 18 | 0.16 | 0.83 | 99.45 | | | | | | |
| 19 | 0.11 | 0.55 | 100.00 | | | | | | |

Table (E.4): Rotated component matrix for the final run of energy management adoption drivers.

| Item | Component | | | |
|---|---|---|---|---|
| | 1 | 2 | 3 | 4 |
| DEM19 | 0.89 | | | |
| DEM22 | 0.81 | | | |
| DEM26 | 0.77 | | | |
| DEM21 | 0.76 | | | |
| DEM4 | 0.73 | | | |
| DEM20 | 0.72 | | | |
| DEM17 | 0.71 | | | |
| DEM18 | 0.66 | | | |
| DEM2 | | 0.85 | | |
| DEM10 | | 0.81 | | |
| DEM3 | | 0.80 | | |
| DEM1 | | 0.75 | | |
| DEM6 | | | 0.88 | |
| DEM9 | | | 0.82 | |
| DEM7 | | | 0.81 | |
| DEM15 | | | 0.72 | |
| DEM11 | | | | 0.80 |
| DEM13 | | | | 0.78 |
| DEM24 | | | | 0.77 |

➢ **Results of the final run of the factor analysis for energy management adoption barriers**

Table (E.5): Correlation matrix for energy management adoption barriers "Final run"

| | BEM 1 | BEM 3 | BEM 4 | BEM 5 | BEM 6 | BEM 7 | BEM 8 | BEM 9 | BEM 10 | BEM 11 | BEM 12 | BEM 13 | BEM 15 | BEM 16 | BEM 17 | BEM 18 | BEM 19 | BEM 20 | BEM 21 | BEM 22 | BEM 23 | BEM 24 | BEM 26 | BEM 27 | BEM 28 | BEM 29 | BEM 30 | BEM 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BEM1 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| BEM3 | 0.62 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | |
| BEM4 | 0.70 | 0.63 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | |
| BEM5 | 0.55 | 0.59 | 0.51 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | |
| BEM6 | 0.09 | 0.22 | 0.13 | 0.25 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | |
| BEM7 | -0.02 | 0.14 | -0.01 | 0.17 | 0.00 | 1.00 | | | | | | | | | | | | | | | | | | | | | | |
| BEM8 | -0.03 | 0.05 | 0.08 | 0.07 | 0.00 | -0.09 | 1.00 | | | | | | | | | | | | | | | | | | | | | |
| BEM9 | 0.78 | 0.65 | 0.74 | 0.54 | 0.13 | -0.06 | 0.00 | 1.00 | | | | | | | | | | | | | | | | | | | | |
| BEM10 | 0.07 | 0.25 | 0.03 | 0.06 | -0.13 | 0.45 | -0.20 | -0.02 | 1.00 | | | | | | | | | | | | | | | | | | | |
| BEM11 | 0.07 | 0.18 | 0.15 | 0.16 | -0.21 | 0.52 | 0.12 | 0.05 | 0.43 | 1.00 | | | | | | | | | | | | | | | | | | |
| BEM12 | 0.19 | 0.17 | 0.06 | 0.11 | 0.42 | -0.13 | 0.07 | 0.11 | -0.31 | -0.12 | 1.00 | | | | | | | | | | | | | | | | | |
| BEM13 | 0.07 | 0.13 | 0.06 | 0.09 | -0.03 | 0.52 | 0.01 | 0.05 | 0.48 | 0.42 | -0.11 | 1.00 | | | | | | | | | | | | | | | | |
| BEM15 | 0.58 | 0.51 | 0.65 | 0.53 | 0.10 | -0.01 | 0.06 | 0.71 | -0.07 | -0.03 | -0.06 | 0.01 | 1.00 | | | | | | | | | | | | | | | |
| BEM16 | 0.05 | 0.24 | 0.06 | 0.03 | 0.07 | 0.49 | -0.16 | -0.07 | 0.48 | 0.34 | -0.07 | 0.41 | -0.06 | 1.00 | | | | | | | | | | | | | | |
| BEM17 | 0.05 | 0.22 | 0.08 | -0.01 | -0.07 | 0.32 | -0.22 | 0.03 | 0.43 | 0.40 | -0.02 | 0.44 | 0.01 | 0.36 | 1.00 | | | | | | | | | | | | | |
| BEM18 | -0.09 | -0.01 | -0.12 | 0.09 | 0.03 | 0.04 | 0.43 | -0.05 | -0.05 | 0.13 | 0.05 | 0.07 | -0.03 | -0.05 | -0.09 | 1.00 | | | | | | | | | | | | |
| BEM19 | -0.10 | -0.06 | -0.09 | 0.04 | 0.14 | -0.04 | 0.47 | -0.15 | -0.02 | 0.01 | 0.07 | 0.00 | -0.02 | -0.19 | -0.15 | 0.53 | 1.00 | | | | | | | | | | | |
| BEM20 | -0.05 | -0.05 | -0.04 | 0.16 | 0.03 | 0.02 | 0.42 | -0.13 | -0.14 | 0.03 | 0.02 | 0.14 | 0.14 | -0.16 | -0.16 | 0.45 | 0.64 | 1.00 | | | | | | | | | | |
| BEM21 | 0.04 | 0.17 | 0.08 | 0.18 | -0.06 | -0.06 | 0.45 | 0.06 | -0.13 | 0.15 | 0.02 | 0.03 | 0.05 | -0.16 | -0.16 | 0.64 | 0.50 | 0.38 | 1.00 | | | | | | | | | |
| BEM22 | 0.08 | 0.29 | 0.09 | 0.14 | 0.03 | 0.54 | -0.12 | -0.03 | 0.53 | 0.39 | -0.06 | 0.46 | -0.04 | 0.57 | 0.54 | -0.09 | -0.18 | -0.10 | -0.16 | 1.00 | | | | | | | | |
| BEM23 | -0.20 | -0.07 | -0.16 | 0.08 | 0.01 | 0.10 | 0.49 | -0.20 | -0.09 | 0.17 | -0.07 | 0.05 | -0.09 | -0.13 | -0.22 | 0.46 | 0.70 | 0.50 | 0.53 | -0.19 | 1.00 | | | | | | | |
| BEM24 | -0.12 | -0.02 | -0.09 | -0.03 | 0.06 | 0.03 | 0.40 | -0.12 | -0.11 | 0.04 | 0.05 | 0.03 | -0.02 | -0.20 | -0.22 | 0.50 | 0.68 | 0.54 | 0.42 | -0.20 | 0.70 | 1.00 | | | | | | |
| BEM26 | 0.12 | 0.02 | 0.01 | 0.12 | 0.42 | -0.10 | 0.07 | 0.05 | -0.23 | -0.08 | 0.59 | -0.10 | -0.05 | -0.10 | -0.07 | 0.10 | 0.15 | 0.10 | 0.03 | -0.04 | 0.04 | 0.16 | 1.00 | | | | | |
| BEM27 | 0.15 | 0.12 | 0.11 | 0.15 | 0.47 | -0.08 | 0.12 | 0.19 | -0.30 | -0.05 | 0.55 | -0.15 | 0.15 | -0.08 | -0.12 | 0.10 | 0.11 | 0.16 | 0.07 | 0.00 | 0.10 | 0.18 | 0.72 | 1.00 | | | | |
| BEM28 | 0.11 | 0.16 | 0.19 | 0.15 | 0.58 | 0.03 | 0.00 | 0.13 | -0.16 | 0.03 | 0.52 | -0.03 | 0.08 | 0.09 | -0.09 | 0.09 | 0.16 | 0.16 | 0.01 | 0.15 | 0.07 | 0.16 | 0.46 | 0.60 | 1.00 | | | |
| BEM29 | 0.12 | 0.15 | 0.14 | 0.15 | 0.42 | -0.01 | 0.06 | 0.07 | -0.22 | 0.00 | 0.59 | -0.09 | -0.04 | 0.02 | -0.10 | 0.04 | 0.19 | 0.12 | 0.00 | 0.07 | 0.07 | 0.21 | 0.62 | 0.54 | 0.55 | 1.00 | | |
| BEM30 | 0.13 | 0.13 | 0.17 | 0.11 | 0.59 | 0.03 | -0.10 | 0.13 | -0.11 | -0.17 | 0.49 | -0.14 | 0.01 | 0.11 | -0.15 | 0.02 | 0.13 | 0.00 | -0.04 | 0.05 | -0.07 | 0.10 | 0.47 | 0.52 | 0.59 | 0.57 | 1.00 | |
| BEM31 | -0.05 | 0.16 | 0.19 | 0.12 | 0.42 | 0.04 | 0.05 | 0.07 | -0.22 | 0.03 | 0.50 | 0.04 | 0.02 | 0.03 | -0.12 | 0.07 | -0.01 | 0.00 | 0.01 | 0.13 | 0.00 | 0.15 | 0.44 | 0.51 | 0.64 | 0.58 | 0.52 | 1.00 |

Table (E.6): Anti-image correlation matrix for energy management adoption barriers “Final run”

| | BEM1 | BEM3 | BEM4 | BEM5 | BEM6 | BEM7 | BEM8 | BEM9 | BEM10 | BEM11 | BEM12 | BEM13 | BEM15 | BEM16 | BEM17 | BEM18 | BEM19 | BEM20 | BEM21 | BEM22 | BEM23 | BEM24 | BEM26 | BEM27 | BEM28 | BEM29 | BEM30 | BEM31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BEM1 | 0.78[a] | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| BEM3 | -0.11 | 0.68[a] | | | | | | | | | | | | | | | | | | | | | | | | | | |
| BEM4 | -0.32 | -0.08 | 0.81[a] | | | | | | | | | | | | | | | | | | | | | | | | | |
| BEM5 | -0.15 | -0.21 | -0.03 | 0.74[a] | | | | | | | | | | | | | | | | | | | | | | | | |
| BEM6 | 0.13 | -0.23 | 0.01 | -0.24 | 0.75[a] | | | | | | | | | | | | | | | | | | | | | | | |
| BEM7 | 0.08 | 0.00 | 0.10 | -0.10 | -0.05 | 0.75[a] | | | | | | | | | | | | | | | | | | | | | | |
| BEM8 | 0.13 | -0.10 | -0.22 | 0.15 | -0.11 | 0.15 | 0.69[a] | | | | | | | | | | | | | | | | | | | | | |
| BEM9 | -0.34 | -0.36 | -0.19 | -0.06 | 0.11 | 0.03 | 0.00 | 0.72[a] | | | | | | | | | | | | | | | | | | | | |
| BEM10 | 0.02 | -0.39 | 0.02 | -0.01 | 0.09 | 0.02 | 0.21 | 0.16 | 0.68[a] | | | | | | | | | | | | | | | | | | | |
| BEM11 | -0.02 | 0.16 | -0.14 | -0.12 | 0.23 | -0.36 | -0.24 | -0.10 | -0.30 | 0.63[a] | | | | | | | | | | | | | | | | | | |
| BEM12 | -0.26 | -0.21 | 0.22 | -0.04 | 0.06 | -0.06 | -0.20 | 0.10 | 0.18 | 0.08 | 0.78[a] | | | | | | | | | | | | | | | | | |
| BEM13 | -0.10 | 0.35 | 0.06 | 0.07 | -0.21 | -0.25 | -0.07 | -0.34 | -0.35 | 0.08 | -0.08 | 0.55[a] | | | | | | | | | | | | | | | | |
| BEM15 | -0.01 | 0.00 | -0.23 | -0.20 | 0.01 | -0.16 | -0.02 | -0.34 | 0.05 | 0.21 | 0.17 | 0.12 | 0.77[a] | | | | | | | | | | | | | | | |
| BEM16 | -0.08 | -0.27 | -0.06 | 0.15 | 0.00 | -0.11 | 0.02 | 0.31 | -0.03 | -0.10 | 0.05 | -0.24 | -0.10 | 0.74[a] | | | | | | | | | | | | | | |
| BEM17 | 0.21 | -0.22 | -0.14 | 0.17 | -0.06 | 0.13 | 0.32 | 0.06 | 0.13 | -0.35 | -0.25 | -0.29 | -0.14 | 0.06 | 0.60[a] | | | | | | | | | | | | | |
| BEM18 | 0.01 | 0.20 | 0.22 | -0.10 | -0.07 | -0.05 | -0.18 | -0.22 | -0.09 | 0.01 | 0.00 | 0.15 | 0.06 | -0.21 | -0.12 | 0.70[a] | | | | | | | | | | | | |
| BEM19 | -0.05 | 0.20 | -0.01 | 0.09 | -0.14 | 0.06 | -0.20 | -0.04 | -0.36 | 0.15 | -0.08 | 0.17 | -0.07 | 0.08 | -0.19 | -0.07 | 0.74[a] | | | | | | | | | | | |
| BEM20 | 0.01 | -0.11 | -0.02 | -0.23 | 0.19 | 0.03 | -0.08 | 0.36 | 0.24 | -0.03 | 0.07 | -0.39 | -0.24 | 0.12 | 0.12 | -0.16 | -0.38 | 0.65[a] | | | | | | | | | | |
| BEM21 | 0.03 | -0.36 | -0.13 | 0.00 | 0.17 | 0.11 | 0.05 | 0.14 | 0.25 | -0.16 | 0.01 | -0.21 | 0.06 | 0.14 | 0.16 | -0.51 | -0.20 | 0.09 | 0.68[a] | | | | | | | | | |
| BEM22 | -0.13 | -0.13 | 0.07 | -0.16 | 0.16 | -0.30 | -0.25 | 0.17 | -0.20 | 0.15 | 0.27 | -0.07 | 0.12 | -0.15 | -0.39 | 0.03 | 0.03 | 0.01 | 0.00 | 0.72[a] | | | | | | | | |
| BEM23 | 0.09 | -0.03 | 0.06 | -0.29 | 0.03 | -0.15 | -0.15 | 0.07 | 0.13 | -0.11 | 0.15 | -0.07 | 0.11 | -0.09 | 0.07 | 0.14 | -0.40 | 0.16 | -0.19 | 0.16 | 0.75[a] | | | | | | | |
| BEM24 | -0.07 | -0.23 | 0.03 | 0.28 | 0.09 | -0.07 | 0.04 | 0.07 | 0.02 | 0.01 | 0.11 | -0.08 | -0.06 | 0.17 | 0.05 | -0.24 | -0.18 | -0.14 | 0.16 | 0.09 | -0.41 | 0.79[a] | | | | | | |
| BEM26 | -0.14 | 0.13 | 0.03 | -0.17 | -0.06 | 0.02 | -0.03 | 0.07 | -0.08 | 0.04 | -0.11 | -0.04 | 0.12 | 0.04 | -0.10 | -0.05 | -0.05 | 0.07 | 0.00 | 0.10 | 0.10 | -0.05 | 0.81[a] | | | | | |
| BEM27 | -0.01 | 0.07 | 0.17 | 0.17 | -0.12 | 0.06 | -0.06 | -0.18 | 0.00 | -0.08 | -0.11 | 0.19 | -0.21 | 0.00 | -0.02 | 0.07 | 0.24 | -0.19 | -0.09 | -0.15 | -0.22 | -0.01 | -0.53 | 0.78[a] | | | | |
| BEM28 | -0.01 | 0.10 | -0.09 | 0.15 | -0.35 | 0.11 | 0.25 | -0.11 | 0.02 | -0.20 | -0.21 | 0.12 | 0.00 | -0.09 | 0.14 | -0.02 | -0.07 | -0.21 | 0.04 | -0.24 | -0.12 | 0.05 | 0.07 | -0.15 | 0.80[a] | | | |
| BEM29 | 0.00 | -0.09 | -0.07 | -0.01 | 0.01 | 0.02 | 0.09 | 0.01 | 0.17 | -0.14 | -0.18 | 0.04 | 0.10 | -0.05 | 0.10 | 0.09 | -0.16 | -0.04 | 0.11 | -0.13 | 0.01 | -0.08 | -0.30 | 0.04 | 0.01 | 0.87[a] | | |
| BEM30 | -0.01 | 0.18 | -0.13 | 0.02 | -0.29 | -0.19 | 0.14 | -0.14 | -0.14 | 0.17 | -0.11 | 0.21 | 0.15 | -0.20 | 0.08 | 0.05 | -0.16 | 0.00 | -0.11 | 0.00 | 0.17 | -0.10 | 0.04 | -0.15 | -0.05 | -0.16 | 0.81[a] | |
| BEM31 | 0.40 | -0.20 | -0.26 | -0.08 | 0.11 | 0.05 | 0.02 | 0.14 | 0.19 | -0.08 | -0.15 | -0.33 | -0.08 | 0.15 | 0.25 | -0.15 | 0.08 | 0.25 | 0.09 | -0.12 | 0.09 | -0.14 | -0.03 | -0.10 | -0.31 | -0.18 | -0.16 | 0.70[a] |

Table (E.7): Total variance explained by factor analysis for the final run of the barriers for energy management adoption

| Component | Initial Eigenvalues | | | Extraction Sums of Squared Loadings | | | Rotation Sums of Squared Loadings | | |
|---|---|---|---|---|---|---|---|---|---|
| | Total | % of Variance | Cumulative % | Total | % of Variance | Cumulative % | Total | % of Variance | Cumulative % |
| 1 | 5.48 | 19.57 | 19.56 | 5.48 | 19.57 | 19.56 | 4.88 | 18.24 | 18.24 |
| 2 | 4.92 | 17.57 | 37.13 | 4.92 | 17.57 | 37.13 | 4.31 | 15.80 | 34.04 |
| 3 | 3.74 | 13.36 | 50.49 | 3.74 | 13.36 | 50.49 | 4.19 | 14.98 | 49.02 |
| 4 | 3.47 | 12.39 | 62.88 | 3.47 | 12.39 | 62.88 | 3.86 | 13.86 | 62.88 |
| 5 | 0.91 | 3.25 | 66.13 | | | | | | |
| 6 | 0.88 | 3.14 | 69.27 | | | | | | |
| 7 | 0.83 | 2.96 | 72.24 | | | | | | |
| 8 | 0.73 | 2.61 | 74.84 | | | | | | |
| 9 | 0.70 | 2.50 | 77.34 | | | | | | |
| 10 | 0.64 | 2.29 | 79.63 | | | | | | |
| 11 | 0.60 | 2.14 | 81.77 | | | | | | |
| 12 | 0.57 | 2.04 | 83.81 | | | | | | |
| 13 | 0.54 | 1.93 | 85.74 | | | | | | |
| 14 | 0.48 | 1.71 | 87.45 | | | | | | |
| 15 | 0.46 | 1.64 | 89.09 | | | | | | |
| 16 | 0.40 | 1.43 | 90.52 | | | | | | |
| 17 | 0.38 | 1.36 | 91.88 | | | | | | |
| 18 | 0.36 | 1.29 | 93.17 | | | | | | |
| 19 | 0.31 | 1.11 | 94.27 | | | | | | |
| 20 | 0.29 | 1.04 | 95.31 | | | | | | |
| 21 | 0.25 | 0.89 | 96.20 | | | | | | |
| 22 | 0.21 | 0.75 | 96.95 | | | | | | |
| 23 | 0.19 | 0.68 | 97.63 | | | | | | |
| 24 | 0.18 | 0.64 | 98.27 | | | | | | |
| 25 | 0.15 | 0.54 | 98.81 | | | | | | |
| 26 | 0.13 | 0.46 | 99.27 | | | | | | |
| 27 | 0.11 | 0.39 | 99.67 | | | | | | |
| 28 | 0.10 | 0.35 | 100.00 | | | | | | |

Table (E.8): Rotated component matrix for the final run of energy management adoption barriers.

| Item | Component | | | |
|---|---|---|---|---|
| | 1 | 2 | 3 | 4 |
| BEM29 | 0.80 | | | |
| BEM27 | 0.79 | | | |
| BEM26 | 0.79 | | | |
| BEM12 | 0.79 | | | |
| BEM28 | 0.77 | | | |
| BEM31 | 0.76 | | | |
| BEM30 | 0.72 | | | |
| BEM6 | 0.62 | | | |
| BEM23 | | 0.84 | | |
| BEM19 | | 0.84 | | |
| BEM24 | | 0.79 | | |
| BEM20 | | 0.74 | | |
| BEM18 | | 0.73 | | |
| BEM21 | | 0.72 | | |
| BEM8 | | 0.65 | | |
| BEM9 | | | 0.90 | |
| BEM4 | | | 0.85 | |
| BEM1 | | | 0.85 | |
| BEM15 | | | 0.82 | |
| BEM3 | | | 0.78 | |
| BEM5 | | | 0.73 | |
| BEM22 | | | | 0.80 |
| BEM7 | | | | 0.77 |
| BEM10 | | | | 0.74 |
| BEM16 | | | | 0.73 |
| BEM13 | | | | 0.72 |
| BEM11 | | | | 0.66 |
| BEM17 | | | | 0.63 |

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

➢ **Results of the final run of the factor analysis for best activities to save energy in construction**

Table (E.9): Correlation matrix for the best activities for energy saving "Final run"

| Item | SEM1 | SEM2 | SEM4 | SEM5 | SEM6 | SEM7 | SEM9 | SEM10 | SEM12 | SEM13 | SEM15 | SEM16 | SEM18 | SEM19 | SEM20 | SEM22 | SEM23 | SEM24 | SEM25 | SEM26 | SEM27 | SEM28 | SEM29 | SEM30 | SEM31 | SEM32 | SEM33 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SEM1 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | |
| SEM2 | 0.52 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | |
| SEM4 | 0.02 | -0.01 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | |
| SEM5 | 0.04 | -0.04 | -0.09 | 1.00 | | | | | | | | | | | | | | | | | | | | | | | |
| SEM6 | 0.37 | 0.52 | 0.01 | 0.00 | 1.00 | | | | | | | | | | | | | | | | | | | | | | |
| SEM7 | -0.01 | 0.03 | -0.09 | 0.50 | -0.16 | 1.00 | | | | | | | | | | | | | | | | | | | | | |
| SEM9 | 0.57 | 0.39 | 0.05 | -0.12 | 0.42 | -0.16 | 1.00 | | | | | | | | | | | | | | | | | | | | |
| SEM10 | -0.18 | 0.00 | 0.39 | -0.10 | 0.07 | 0.01 | -0.01 | 1.00 | | | | | | | | | | | | | | | | | | | |
| SEM12 | 0.45 | 0.46 | -0.01 | -0.04 | 0.44 | 0.01 | 0.43 | 0.09 | 1.00 | | | | | | | | | | | | | | | | | | |
| SEM13 | 0.03 | -0.07 | -0.07 | 0.53 | -0.18 | 0.57 | -0.24 | -0.07 | -0.06 | 1.00 | | | | | | | | | | | | | | | | | |
| SEM15 | -0.06 | -0.05 | 0.76 | -0.09 | 0.08 | -0.02 | 0.08 | 0.58 | 0.04 | -0.06 | 1.00 | | | | | | | | | | | | | | | | |
| SEM16 | -0.12 | -0.12 | 0.60 | -0.03 | 0.02 | 0.03 | -0.04 | 0.59 | -0.02 | -0.05 | 0.58 | 1.00 | | | | | | | | | | | | | | | |
| SEM18 | -0.05 | -0.04 | 0.54 | -0.09 | 0.17 | -0.01 | 0.07 | 0.56 | 0.09 | -0.06 | 0.64 | 0.64 | 1.00 | | | | | | | | | | | | | | |
| SEM19 | -0.01 | -0.01 | 0.54 | -0.10 | 0.26 | -0.09 | 0.17 | 0.59 | 0.18 | -0.11 | 0.73 | 0.50 | 0.67 | 1.00 | | | | | | | | | | | | | |
| SEM20 | -0.08 | -0.04 | 0.56 | -0.11 | 0.10 | 0.02 | 0.00 | 0.79 | 0.13 | -0.04 | 0.65 | 0.79 | 0.59 | 0.55 | 1.00 | | | | | | | | | | | | |
| SEM22 | 0.14 | 0.13 | -0.06 | 0.16 | 0.04 | 0.04 | 0.09 | 0.14 | 0.08 | -0.05 | 0.00 | 0.02 | 0.05 | 0.05 | 0.02 | 1.00 | | | | | | | | | | | |
| SEM23 | 0.02 | -0.01 | -0.01 | 0.09 | -0.05 | 0.07 | -0.09 | 0.22 | 0.10 | 0.08 | -0.02 | 0.10 | 0.01 | 0.16 | 0.09 | 0.52 | 1.00 | | | | | | | | | | |
| SEM24 | -0.10 | 0.01 | 0.12 | 0.04 | 0.11 | -0.05 | -0.07 | 0.21 | 0.00 | -0.04 | 0.13 | 0.12 | 0.06 | 0.19 | 0.14 | 0.63 | 0.71 | 1.00 | | | | | | | | | |
| SEM25 | -0.07 | -0.06 | -0.07 | 0.77 | -0.02 | 0.59 | -0.17 | -0.10 | -0.04 | 0.56 | -0.02 | 0.03 | -0.03 | -0.06 | -0.08 | 0.12 | 0.19 | 0.18 | 1.00 | | | | | | | | |
| SEM26 | 0.49 | 0.47 | 0.05 | -0.06 | 0.48 | -0.17 | 0.52 | -0.08 | 0.68 | -0.23 | 0.14 | -0.15 | -0.08 | 0.10 | -0.03 | 0.03 | -0.08 | 0.05 | -0.12 | 1.00 | | | | | | | |
| SEM27 | 0.02 | -0.03 | -0.06 | 0.16 | 0.05 | 0.14 | -0.03 | 0.20 | 0.06 | 0.10 | 0.03 | -0.06 | 0.08 | 0.15 | 0.00 | 0.42 | 0.50 | 0.48 | 0.20 | -0.02 | 1.00 | | | | | | |
| SEM28 | 0.21 | 0.14 | 0.05 | 0.16 | 0.27 | 0.01 | 0.17 | 0.20 | 0.10 | -0.01 | 0.02 | 0.23 | 0.14 | 0.11 | 0.23 | 0.59 | 0.58 | 0.47 | 0.13 | 0.00 | 0.36 | 1.00 | | | | | |
| SEM29 | 0.03 | 0.01 | -0.07 | 0.08 | 0.08 | -0.03 | 0.18 | 0.19 | -0.04 | -0.11 | -0.07 | -0.01 | 0.04 | 0.15 | 0.00 | 0.40 | 0.59 | 0.47 | 0.13 | -0.07 | 0.58 | 0.60 | 1.00 | | | | |
| SEM30 | -0.03 | 0.00 | -0.14 | 0.62 | -0.03 | 0.64 | -0.18 | -0.03 | 0.00 | 0.50 | -0.16 | 0.04 | -0.05 | -0.09 | -0.03 | 0.15 | 0.25 | 0.23 | 0.75 | -0.16 | 0.22 | 0.18 | 0.21 | 1.00 | | | |
| SEM31 | -0.02 | 0.00 | -0.16 | 0.58 | -0.07 | 0.74 | -0.17 | -0.08 | -0.01 | 0.58 | -0.15 | -0.02 | -0.04 | -0.24 | -0.06 | 0.12 | 0.10 | 0.08 | 0.67 | -0.17 | 0.18 | 0.12 | 0.05 | 0.79 | 1.00 | | |
| SEM32 | 0.00 | 0.00 | -0.16 | 0.44 | 0.03 | 0.40 | -0.14 | -0.12 | -0.07 | 0.46 | -0.06 | -0.09 | -0.12 | -0.09 | -0.09 | -0.02 | 0.08 | 0.08 | 0.43 | -0.11 | 0.20 | 0.02 | -0.02 | 0.40 | 0.38 | 1.00 | |
| SEM33 | -0.09 | -0.07 | 0.41 | -0.01 | 0.12 | 0.03 | -0.04 | 0.34 | 0.03 | 0.01 | 0.49 | 0.56 | 0.70 | 0.53 | 0.44 | -0.12 | -0.02 | 0.00 | 0.10 | -0.04 | -0.14 | -0.04 | -0.07 | 0.02 | -0.02 | -0.11 | 1.00 |

Table (E.10): Anti-image correlation matrix for energy saving activities "Final run"

| Item | SEM1 | SEM2 | SEM4 | SEM5 | SEM6 | SEM7 | SEM9 | SEM10 | SEM12 | SEM13 | SEM15 | SEM16 | SEM18 | SEM19 | SEM20 | SEM22 | SEM23 | SEM24 | SEM25 | SEM26 | SEM27 | SEM28 | SEM29 | SEM30 | SEM31 | SEM32 | SEM33 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SEM1 | **0.68**[a] | | | | | | | | | | | | | | | | | | | | | | | | | | |
| SEM2 | -0.25 | **0.70**[a] | | | | | | | | | | | | | | | | | | | | | | | | | |
| SEM4 | -0.13 | -0.21 | 0.73[a] | | | | | | | | | | | | | | | | | | | | | | | | |
| SEM5 | -0.05 | 0.15 | -0.20 | **0.74**[a] | | | | | | | | | | | | | | | | | | | | | | | |
| SEM6 | -0.10 | -0.38 | 0.16 | -0.02 | **0.57**[a] | | | | | | | | | | | | | | | | | | | | | | |
| SEM7 | 0.04 | -0.18 | 0.06 | 0.01 | 0.16 | **0.86**[a] | | | | | | | | | | | | | | | | | | | | | |
| SEM9 | -0.38 | 0.04 | 0.02 | 0.08 | -0.08 | -0.03 | **0.75**[a] | | | | | | | | | | | | | | | | | | | | |
| SEM10 | 0.24 | -0.24 | 0.25 | -0.18 | -0.04 | 0.02 | -0.04 | **0.74**[a] | | | | | | | | | | | | | | | | | | | |
| SEM12 | 0.05 | -0.07 | -0.09 | 0.16 | -0.10 | -0.01 | -0.12 | 0.00 | **0.56**[a] | | | | | | | | | | | | | | | | | | |
| SEM13 | -0.22 | 0.00 | -0.05 | -0.11 | 0.17 | -0.10 | 0.06 | -0.06 | -0.03 | **0.84**[a] | | | | | | | | | | | | | | | | | |
| SEM15 | 0.03 | 0.08 | -0.55 | 0.22 | 0.14 | -0.07 | -0.01 | -0.20 | 0.34 | 0.05 | **0.70**[a] | | | | | | | | | | | | | | | | |
| SEM16 | 0.02 | 0.06 | -0.26 | 0.03 | 0.06 | -0.01 | -0.08 | 0.01 | 0.11 | 0.17 | 0.12 | **0.84**[a] | | | | | | | | | | | | | | | |
| SEM18 | -0.02 | 0.01 | -0.08 | 0.04 | -0.04 | 0.06 | -0.05 | -0.13 | -0.19 | 0.04 | -0.14 | -0.18 | **0.82**[a] | | | | | | | | | | | | | | |
| SEM19 | 0.04 | 0.15 | 0.01 | -0.10 | -0.32 | -0.08 | -0.11 | -0.10 | -0.17 | -0.08 | -0.46 | 0.03 | -0.17 | **0.79**[a] | | | | | | | | | | | | | |
| SEM20 | -0.12 | 0.12 | -0.04 | 0.07 | 0.01 | -0.07 | 0.09 | -0.60 | -0.24 | -0.04 | -0.17 | -0.48 | 0.12 | 0.07 | **0.76**[a] | | | | | | | | | | | | |
| SEM22 | -0.18 | -0.17 | 0.25 | -0.23 | 0.35 | -0.07 | -0.08 | -0.10 | -0.15 | 0.17 | -0.11 | -0.01 | -0.07 | -0.03 | 0.18 | **0.58**[a] | | | | | | | | | | | |
| SEM23 | -0.23 | -0.02 | 0.08 | 0.05 | 0.34 | -0.08 | 0.19 | -0.17 | -0.37 | -0.04 | 0.03 | -0.09 | 0.19 | -0.16 | 0.20 | 0.18 | **0.64**[a] | | | | | | | | | | |
| SEM24 | 0.30 | 0.07 | -0.26 | 0.23 | -0.32 | 0.19 | 0.02 | 0.08 | 0.32 | -0.03 | 0.07 | 0.06 | 0.02 | 0.03 | -0.16 | -0.57 | -0.57 | **0.57**[a] | | | | | | | | | |
| SEM25 | 0.15 | -0.01 | 0.13 | -0.55 | -0.13 | -0.09 | -0.06 | 0.20 | -0.12 | -0.16 | -0.31 | -0.09 | 0.08 | 0.15 | 0.06 | 0.04 | -0.07 | -0.08 | **0.78**[a] | | | | | | | | |
| SEM26 | -0.17 | -0.13 | 0.18 | -0.25 | -0.07 | 0.02 | -0.15 | 0.10 | -0.63 | 0.13 | -0.44 | 0.03 | 0.25 | 0.15 | 0.07 | 0.18 | 0.20 | -0.33 | 0.14 | **0.60**[a] | | | | | | | |
| SEM27 | -0.14 | 0.15 | 0.03 | 0.02 | -0.07 | -0.07 | 0.23 | -0.12 | -0.09 | -0.06 | -0.03 | 0.04 | -0.21 | -0.03 | 0.09 | -0.11 | -0.02 | -0.12 | -0.04 | -0.04 | **0.72**[a] | | | | | | |
| SEM28 | -0.02 | 0.04 | -0.01 | -0.12 | -0.41 | 0.05 | 0.01 | 0.25 | 0.10 | -0.11 | -0.02 | -0.14 | -0.12 | 0.15 | -0.28 | -0.45 | -0.38 | 0.21 | 0.09 | 0.00 | 0.12 | **0.64**[a] | | | | | |
| SEM29 | 0.09 | -0.03 | -0.05 | 0.04 | 0.14 | 0.04 | -0.35 | -0.17 | 0.20 | 0.21 | 0.14 | 0.15 | 0.04 | -0.11 | 0.08 | 0.18 | -0.19 | 0.00 | -0.09 | -0.01 | -0.45 | -0.43 | **0.66**[a] | | | | |
| SEM30 | -0.12 | -0.06 | -0.02 | -0.05 | 0.11 | -0.08 | 0.12 | -0.04 | -0.05 | 0.07 | 0.25 | -0.10 | 0.04 | -0.25 | -0.01 | 0.10 | 0.09 | -0.20 | -0.33 | 0.00 | 0.14 | 0.03 | -0.18 | **0.80**[a] | | | |
| SEM31 | 0.06 | 0.06 | 0.04 | -0.03 | -0.11 | -0.41 | -0.06 | 0.01 | -0.05 | -0.20 | -0.12 | 0.05 | -0.15 | 0.35 | 0.01 | -0.03 | 0.05 | -0.02 | -0.01 | 0.05 | -0.09 | -0.05 | 0.07 | -0.52 | **0.80**[a] | | |
| SEM32 | 0.00 | -0.08 | 0.23 | -0.23 | -0.11 | -0.11 | -0.03 | 0.17 | 0.01 | -0.19 | -0.20 | -0.05 | 0.02 | 0.03 | -0.04 | 0.16 | -0.02 | -0.13 | 0.07 | 0.14 | -0.17 | 0.02 | 0.09 | -0.10 | 0.09 | **0.77**[a] | |
| SEM33 | -0.09 | -0.07 | 0.41 | -0.01 | 0.12 | 0.03 | -0.04 | 0.34 | 0.03 | 0.01 | 0.49 | 0.56 | 0.70 | 0.53 | 0.44 | -0.12 | -0.02 | 0.00 | 0.10 | -0.04 | -0.14 | -0.04 | -0.07 | 0.02 | -0.02 | -0.11 | **0.77a** |

Table (E.11): Total variance explained by factor analysis for the final run of energy saving activities. " Seventh run"

| Component | Initial Eigenvalues | | | Extraction Sums of Squared Loadings | | | Rotation Sums of Squared Loadings | | |
|---|---|---|---|---|---|---|---|---|---|
| | Total | % of Variance | Cumulative % | Total | % of Variance | Cumulative % | Total | % of Variance | Cumulative % |
| 1 | 5.468 | 20.251 | 20.251 | 5.468 | 20.251 | 20.251 | 5.164 | 19.127 | 19.127 |
| 2 | 4.847 | 17.952 | 38.203 | 4.847 | 17.952 | 38.203 | 4.532 | 16.786 | 35.913 |
| 3 | 3.758 | 13.918 | 52.121 | 3.758 | 13.918 | 52.121 | 3.793 | 14.049 | 49.962 |
| 4 | 2.911 | 10.780 | 62.901 | 2.911 | 10.780 | 62.901 | 3.492 | 12.950 | 62.912 |
| 5 | 0.980 | 3.630 | 66.530 | | | | | | |
| 6 | .944 | 3.496 | 70.026 | | | | | | |
| 7 | .891 | 3.300 | 73.326 | | | | | | |
| 8 | .859 | 3.183 | 76.509 | | | | | | |
| 9 | .804 | 2.977 | 79.486 | | | | | | |
| 10 | .677 | 2.506 | 81.992 | | | | | | |
| 11 | .626 | 2.320 | 84.312 | | | | | | |
| 12 | .574 | 2.125 | 86.437 | | | | | | |
| 13 | .498 | 1.846 | 88.283 | | | | | | |
| 14 | .453 | 1.676 | 89.959 | | | | | | |
| 15 | .399 | 1.479 | 91.438 | | | | | | |
| 16 | .346 | 1.283 | 92.721 | | | | | | |
| 17 | .314 | 1.163 | 93.884 | | | | | | |
| 18 | .293 | 1.086 | 94.970 | | | | | | |
| 19 | .251 | .928 | 95.898 | | | | | | |
| 20 | .235 | .870 | 96.769 | | | | | | |
| 21 | .189 | .699 | 97.468 | | | | | | |
| 22 | .164 | .606 | 98.074 | | | | | | |
| 23 | .145 | .536 | 98.609 | | | | | | |
| 24 | .122 | .452 | 99.062 | | | | | | |
| 25 | .106 | .392 | 99.453 | | | | | | |
| 26 | .078 | .290 | 99.743 | | | | | | |
| 27 | .069 | .257 | 99.999 | | | | | | |

Table (E.12): Rotated component matrix for the final run of energy saving activities

| Item | Component | | | |
|---|---|---|---|---|
| | 1 | 2 | 3 | 4 |
| SEM15 | 0.85 | | | |
| SEM20 | 0.84 | | | |
| SEM18 | 0.84 | | | |
| SEM16 | 0.83 | | | |
| SEM19 | 0.79 | | | |
| SEM4 | 0.75 | | | |
| SEM10 | 0.74 | | | |
| SEM33 | 0.72 | | | |
| SEM31 | | 0.86 | | |
| SEM25 | | 0.85 | | |
| SEM30 | | 0.84 | | |
| SEM7 | | 0.81 | | |
| SEM5 | | 0.79 | | |
| SEM13 | | 0.76 | | |
| SEM32 | | 0.59 | | |
| SEM23 | | | 0.83 | |
| SEM24 | | | 0.80 | |
| SEM29 | | | 0.80 | |
| SEM22 | | | 0.75 | |
| SEM28 | | | 0.75 | |
| SEM27 | | | 0.70 | |
| SEM26 | | | | 0.80 |
| SEM1 | | | | 0.76 |
| SEM12 | | | | 0.76 |
| SEM2 | | | | 0.74 |
| SEM9 | | | | 0.73 |
| SEM6 | | | | 0.71 |

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

# Appendix (F)

# Criterion related validity results

Table (F.1) : Criterion related validity for energy management awareness features

| Energy management awareness criteria | Pearson correlation coefficient | P-value (sig.) |
|---|---|---|
| Onsite energy costs represent an important part of the project overall costs. | 0.51 | 0.00 |
| Increased onsite energy use may result in different negative environmental impacts. | 0.67 | 0.00 |
| GHG emissions are the highest negative environmental impact associated with energy use during onsite construction. | 0.65 | 0.00 |
| There is energy efficiency gap in local construction industry. | 0.57 | 0.00 |
| Energy management is one component of the sustainability concept. | 0.57 | 0.00 |
| Energy management improves the company performance (competitive advantage). | 0.68 | 0.00 |
| Adoption of onsite energy management affects the project management method/style. | 0.56 | 0.00 |
| Energy management is one of the construction business ethics. | 0.50 | 0.00 |
| Energy management highly reduces overall project cost. | 0.51 | 0.00 |
| Energy management highly reduces the negative environmental impacts of the project. | 0.59 | 0.00 |

Table (F.2) : Criterion related validity for energy management application requirements

| Energy management application requirements | Pearson correlation coefficient | P-value (sig.) |
|---|---|---|
| My company preparing an environmental management program for each project. | 0.50 | 0.00 |
| My company presenting onsite energy management as one component of its written policy. | 0.60 | 0.00 |
| My company providing a strategy to save onsite energy for each project. | 0.51 | 0.00 |
| My company preparing an energy management plan for each project to save onsite energy . | 0.51 | 0.00 |
| My company establishing an energy saving objectives and targets for all onsite works. | 0.53 | 0.00 |
| My company identifying unique key performance indicators related to onsite energy issues. | 0.66 | 0.00 |

Table (F.2) : Criterion related validity for energy management application requirements “Cont.”

| Energy management application requirements | Pearson correlation coefficient | P-value (sig.) |
|---|---|---|
| My company conducting energy audit and accounting for its onsite works to record and report energy consumption and saving opportunities. | 0.61 | 0.00 |
| My company setting a monitoring system for energy use during onsite works. | 0.61 | 0.00 |
| My company conducting periodic revision of significant historical data related to energy aspects for onsite works. | 0.49 | 0.00 |
| My company conducting regular assessment of its future energy needs. | 0.53 | 0.00 |
| My company regularly assessing the compliance and committing to all legal obligations and other regulatory requirements related to energy aspects for onsite works. | 0.56 | 0.00 |
| My company hiring a specialized committee or person responsible for all energy issues during onsite works. | 0.65 | 0.00 |
| My company providing the required experienced personnel, as well as technical and financial resources to save energy during on site construction. | 0.52 | 0.00 |
| My company introducing incentives for energy saving during onsite construction works. | 0.47 | 0.00 |
| My company creating and using energy manual to save energy during onsite works. | 0.44 | 0.00 |
| My company providing specialized energy management training programs for its employees. | 0.53 | 0.00 |
| My company providing awareness programs and tools to save energy during onsite works. | 0.55 | 0.000 |

Table (F.3) : Criterion related validity for energy management application drivers

| Energy management adoption drivers | Pearson correlation coefficient | P-value (sig.) |
|---|---|---|
| Existence of government regulations related to energy consumption and saving issues for construction industry. | 0.39 | 0.04 |
| Strength and enforcement of the governmental requirements for onsite construction energy saving. | 0.44 | 0.00 |
| Availability of building code requirements for energy saving and management. | 0.30 | 0.04 |
| Imposed governmental tax for energy use and emissions on construction companies. | 0.44 | 0.00 |
| Adoption of energy performance contracts (EPC) in local construction market. | 0.27 | 0.02 |
| Contractor energy performance is one criteria of the company rating in local construction sector . | 0.33 | 0.00 |
| Clients\Donors consideration of contractor energy performance as one criteria of the contractor selection. | 0.24 | 0.03 |
| Government support for researchers in energy management in construction industry. | 0.43 | 0.00 |
| Availability of experts for energy efficiency in construction industry | 0.59 | 0.00 |
| Existence of sustainability policy within the contractor organization. | 0.48 | 0.00 |
| Availability of long term energy management strategies within the construction companies. | 0.61 | 0.00 |
| Top management support to sustainable, energy management and saving activities. | 0.55 | 0.00 |
| Contractor willingness to satisfy client/donor requirements regarding energy issues. | 0.47 | 0.00 |
| Construction employees awareness of onsite energy use and problems. | 0.62 | 0.00 |
| Availability of information on successfully implemented energy management practices in construction. | 0.60 | 0.00 |
| Increased education level of the contractor employees. | 0.46 | 0.00 |
| Availability and frequency of internal training on energy management | 0.35 | 0.00 |
| Rising energy prices in local market. | 0.53 | 0.00 |
| Cost saving gained from adopted energy management strategies. | 0.37 | 0.01 |
| High energy amounts and costs required during onsite works in the project. | 0.29 | 0.01 |

Table (F.3) : Criterion related validity for energy management application drivers “Cont.”

| Energy management adoption drivers | Pearson correlation coefficient | P-value (sig.) |
|---|---|---|
| Decrease price levels of energy saving technology for construction industry. | 0.58 | 0.00 |
| Availability of the financial support for energy saving strategies/plans and investments. | 0.45 | 0.00 |
| Improvement of the company competitive advantage and reputation as a result of adopting energy management in its projects. | 0.25 | 0.03 |
| Improved onsite working conditions. | 0.38 | 0.00 |
| Availability of different energy types, sources and alternatives in local market. | 0.56 | 0.00 |
| Availability of new energy saving solutions, products and tools in local market. | 0.56 | 0.00 |

Table (F.4) : Criterion related validity for energy management application barriers

| Energy management adoption barriers | Pearson correlation coefficient | P-value (sig.) |
|---|---|---|
| Lack of governmental legislations for environment protection and energy conservation in construction sector. | 0.304 | 0.018 |
| Poor enforcement of the governmental legislations related to energy issues in construction industry. | 0.303 | 0.008 |
| Lack of government support/ incentives for energy management in construction industry. | 0.358 | 0.001 |
| Lack of energy management codes and regulation in construction. | 0.263 | 0.048 |
| Lack of audit and quantitative evaluation tools for the energy performance of the construction companies . | 0.448 | 0.000 |
| High competition between the local contracting companies working in the construction sector. | 0.319 | 0.005 |
| Fragmentation of the construction process (Increased industry parties and divided processes). | 0.644 | 0.000 |
| Conflicts of interest within the project members (owner/consultant/contractor). | 0.617 | 0.000 |
| The contract documents do not impose any special conditions/specifications for onsite energy management. | 0.389 | 0.001 |
| Company senior management doesn't provide support for energy saving activities | 0.523 | 0.000 |
| Company management lack interest in onsite energy costs and consumption issues. | 0.571 | 0.000 |

Table (F.4) : Criterion related validity for energy management application barriers "Cont."

| Energy management adoption barriers | Pearson correlation coefficient | P-value (sig.) |
|---|---|---|
| Management is concerned about paying additional costs to the company improve energy efficiency. | 0.494 | 0.000 |
| The company lacks long-term vision and it is short-term oriented. | 0.466 | 0.000 |
| The company lacks of procedures or strategies to promote sustainable construction | 0.537 | 0.000 |
| The company lacks of ethical standards and corporate social responsibility. | 0.567 | 0.000 |
| No specific person or committee assigned to deal with onsite energy issues. | 0.551 | 0.000 |
| Tight project duration makes the management concerned about the time required to adopt energy management practices. | 0.607 | 0.000 |
| Lack of the company staff awareness on the importance of energy management during onsite construction. | 0.554 | 0.000 |
| Lack of the client/donor awareness of the importance of energy management during onsite construction. | 0.598 | 0.000 |
| Resistance to change from traditional practices to more energy efficient practices. | 0.326 | 0.004 |
| Management believe that there is no/little scope for the company energy performance improvement . | 0.558 | 0.000 |
| Difficulties to access technical information and expertise related to energy management in construction. | 0.421 | 0.000 |
| Lack of technical skills\knowledge on construction energy management technologies. | 0.482 | 0.000 |
| Lack of training and education in energy management, sustainable design and construction. | 0.585 | 0.000 |
| Lack of demonstration examples on energy management in construction industry | 0.476 | 0.000 |
| High costs of energy management options (measures/technologies). | 0.359 | 0.001 |
| Construction energy costs are not sufficiently important compared with other costs. | 0.467 | 0.000 |
| Lack of budget funding to adopt energy management practices and technologies. | 0.524 | 0.000 |
| Low profit margins gained from adopting energy management practices. | 0.422 | 0.000 |
| Lack of innovative energy technologies/equipment in local market. | 0.386 | 0.001 |
| Uncertain local economic environment. | 0.429 | 0.000 |

Table (F.5) : Criterion related validity for best activities for energy saving

| Best activities for energy saving | Pearson correlation coefficient | P-value (sig.) |
|---|---|---|
| Company commitment to the governmental regulations related to onsite construction energy consumption and management. | 0.277 | 0.036 |
| Adopting of the governmental fiscal measures related to onsite construction energy issues. | 0.215 | 0.046 |
| Adopting of the available energy code requirements for construction industry. | 0.225 | 0.048 |
| Motivate the company employees to apply more onsite energy saving practices. | 0.353 | 0.002 |
| adoption of more energy efficient construction methods as opposed to traditional construction methods during construction phase. | 0.379 | 0.001 |
| Application of the voluntary agreements (VAs) related to energy issues in local construction sector . | 0.304 | 0.008 |
| Detailed reporting of the company onsite energy activities. | 0.411 | 0.000 |
| Setting a quantitative targets in the company for onsite energy use and saving. | 0.504 | 0.000 |
| Developing scientific, reasonable energy action plan for the project to make full use of onsite energy and resources. | 0.243 | 0.034 |
| Development of adequate energy database in the company. | 0.474 | 0.000 |
| Conducting energy audits on the construction site to identify energy use and energy saving opportunities. | 0.365 | 0.001 |
| Systematic review and analysis for the energy consumption of onsite activities and equipment. | 0.639 | 0.000 |
| Use of a monitoring system for energy use during onsite works. | 0.227 | 0.045 |
| Closer onsite supervision and quality control on energy issues. | 0.256 | 0.026 |
| Using onsite energy manual (detailed work instructions) to save energy during onsite construction. | 0.634 | 0.000 |
| Establishing good onsite communications about energy matters during construction phase. | 0.573 | 0.000 |
| Employing a specialized team or person responsible for all energy issues during onsite works. | 0.558 | 0.000 |
| Conducting periodic meetings and training programs for the contractors staff in energy conservation systems/technologies. | 0.435 | 0.000 |
| Collect information on available energy saving systems, technologies and policies in local construction sector. | 0.576 | 0.000 |
| Compliance with energy experts advices and recommendations during onsite construction. | 0.288 | 0.012 |
| Identification and revision of the performance standards for the equipment used onsite . | 0.472 | 0.000 |

Table (F.5) : Criterion related validity for best activities for energy saving “con’”

| Best activities for energy saving | Pearson correlation coefficient | P-value (sig.) |
|---|---|---|
| Frequent examination of the energy efficiency of all equipment used on construction site. | 0.418 | 0.000 |
| Reducing the unnecessary use of energy consuming equipment and machines used during onsite construction. | 0.182 | 0.048 |
| Replacement of high energy consuming equipment with lower energy consuming equipment. | 0.209 | 0.035 |
| Replacement of onsite mechanical equipment with the use of manual labor where applicable. | 0.575 | 0.000 |
| Practicing of onsite construction methods leading to lower material use . | 0.338 | 0.003 |
| Selecting where possible only local sources of materials supply. | 0.462 | 0.000 |
| Increasing the use of recycled building materials. | 0.614 | 0.000 |
| Reducing excessive material and wastage during onsite construction. | 0.410 | 0.000 |
| Using available energy saving technologies and solutions during onsite construction. | 0.222 | 0.029 |
| Utilization of renewable energies and green technologies for onsite production, transport and performance. | 0.439 | 0.000 |
| Software development for onsite energy monitoring and evaluation. | 0.174 | 0.049 |
| Optimization of the transportation of raw materials and equipment to and within the site. | 0.452 | 0.000 |