Energy Management in Hospitals: A Case Study of the Saudi Ministry of Health

PhD Thesis

By

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Abstract

Huge amount of energy are consumed by hospitals to improve the health environment for patients. This energy needs to be stable and continuous. Therefore, it is necessary to manage energy consumption. The purpose of this research is to study the energy management performance in hospitals in Saudi Arabia aiming to develop theoretical framework for energy management and to provide guideline to support implementing an effective energy management system in hospitals.

This research consists of two main parts. The first part involves the assessment of the level of energy management program and the gathering of energy consumption quantitative data from five hospitals in order to determine the level of implementation of energy management program and the amounts and percentage of annual change in electricity consumption per bed in hospitals. The second part involves the inspection of the opinions of hospital top technical managers regarding energy management in their hospitals and their knowledge in auditing procedures, energy efficiency barriers, awareness to energy management and percentage of expected amount of saved energy.

The research delivers recommendations tailored to the health sector in Saudi Arabia that encourages implementing energy management programs in hospitals to save energy, increase energy efficiency and improve energy management awareness.

Keywords: Energy Management in Hospitals, Barriers to Energy Efficiency, Awareness, Saving Energy.

Dedication

To my Magnificent Parents Saleem and Torush, my wonderful brothers and sisters for their support in my whole life.

Author's Declaration

It is declared that this study is entirely researcher's effort except where otherwise who acknowledged. The material in this thesis is not submitted previously for award any academic degree.

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Chapter 1: Introduction

1.1 Background to Research Problem

In the European Union, energy consumption in residential and public buildings represents over 40% of the total energy that is used by all of the member countries (Directorate General for Energy and Transport, European Commission, 2009). Also, Energy use in commercial and residential buildings has steadily increased by between 20% and 40% in developed countries for the last decade (Pérez-Lombard et al., 2008). In future, it is expected that the EU will be importing 67% of its energy by 2020 (Van Der Linde, 2004).

Moreover, in Saudi Arabia, the peak loads reached approximately 24 GW in year 2001 which represented 25 times the loads level in 1975, obviously this figure is much higher in 2012 as statistics of such figure will be revealed soon. In addition, the expected loads in 2023 are 60 GW approximately (Annual Report for Ministry of Industry and Electricity, 2001). This demand need to meet total investment over $ 90 billion (Al-Ajlan et al., 2006). It is reported that energy consumption in office buildings reached about 70-300 kWh/m2 per annum, which is 10-20 times the energy consumption in residential buildings (Yang et al., 2008). Saidur reported that approximately 32% of total energy consumption in Malaysia is accounted by the commercial sector (including hospitals) (Saidur et al, 2009). Also, Saidur reported that electrical motors for a few selected countries around the world consume approximately 31-75% of total energy (Saidur et al., 2010). In the USA, bout 7% of electricity consumption in all commercial buildings is consumed by health care buildings (US EIA, 2010). The demand on the energy increases every day due to the huge consumption of energy. So, energy management is important issue in recent days. There are many benefits for energy management environmentally, economically and socially. As the demand increases, there is lack of researches in energy management and so far they are rare (Thollander and Ottosson 2010). Researches in energy efficiency mainly concentrated on systems and technical improvements, on the other hand, energy management and organisational improvements have been not ignored (Thollander and Palm, 2013).

The purpose of this research is to study current energy management performance in hospitals in Saudi Arabia. Also, it investigates about energy consumption and barriers to energy efficiency and energy management awareness. In order to achieve aims and objectives of this research, quantitative and qualitative methods are adopted in this research.

1.2 Research Questions

1. What is the actual overall level and characteristics of energy management program in the hospitals?
2. How is energy auditing achieved in hospitals and what are the responsibilities regarding it?
3. What are amount of consumptions and change annually for the energy in the hospitals; what are types of usages and electrical loads and blackout in hospitals and most significant factors effect on energy consumption?
4. What are the barriers to energy efficiency in the hospitals and to what extend they can effect on energy performance in the hospitals?
5. What is the level of awareness of energy management in the hospitals and what are the barriers and drivers to promote it?
6. What are the motivations for energy savings in their organisation and estimating the amount of saved energy?

1.3 Research Aim and Objectives

The research aim is improving energy management performance in Health Care sector through developing the theoretical framework to address the key shortcomings of existing energy management programs and providing practical guidance to implement an energy management in hospitals in Saudi Arabia.

In order to achieve aims of this research, the researcher sets these objectives:

1- Determining and understanding the level and characteristics of energy management programs in hospitals.
2- Exploring the barriers energy efficiency and their affects.
3- Assessing the awareness of and factors in energy management.
4- Energy auditing procedures and how to produce information regarding them.
5- Exploring the opportunities and motivations for energy savings and estimating the amount of expected saved energy.

1.4 Research Motivations

The demand increases to do researches in energy management in hospitals especially. Hospitals are major sector and established to provide services for people without considering their costs and profitability. Hospitals consume a large amount of energy and needs to apply energy management strategies on its systems. Also, there are some challenges in energy management in hospitals which make the management process harder and complicated. As (Brett et al., 2009) and (Velimir et al., 2012) state these are some of the challenges in energy management in hospitals:

1. Hospitals work 24 hours, so some of appliances could be switched-on all times.
2. The requirements for air flirtation and infection control in medical devices to meet the standards make the process more complex to save energy.
3. Hospital buildings are designed to serve for 50-100 years.
4. Some of the medical imaging equipment requires more energy to provide better resolution.
5. Medical devices designers do not consider energy efficiency as a priority.
6. The demand to provide maximum comfort and all the necessary conditions in medical environment to help and treat patients.

Furthermore, research shows that the demands on electricity in hospitals can be characterized by the need for continuous electric supply at high quality (Szklo et al., 2004)

1.5 Research Contributions

The main contributions result for achieving aims and objectives of this research are:

1. The research developed theoretical framework through reviewing various concepts and studies related to energy management and energy efficiency. This framework may be considered valuable due its covering many aspects in energy management.
2. The research provides guidance to implement energy management program which has many advantages. This guidance is built on theoretical and practical data based on real and updated reports in hospitals. Also, this guidance is simple and easy to follow and built on top managers' experiences.
3. The research provided better and clear understanding about energy management performance and updated data for energy consumption attributes in hospitals in Saudi Arabia. Also, the research provided clear and better understanding for level of awareness to energy management.
4. The research demonstrated energy efficiency barriers, their risks and gave recommendations in how to remove these barriers.
5. The researcher selected in this research multiple methods approach and used multiple methods in collecting data that is considered most suitable for a field such energy management. As the majority of energy management researches are conducted by using quantitative or qualitative methods, this study contributes to the literature by linking the qualitative and quantitative research methods.

1.6 Thesis Outline

This thesis is consisted of seven chapters which are presented as follow:

- Chapter One: this chapter presents content of the thesis. It starts by giving background to research problems then aims and objectives of the research. It also presents motivation of this study, the achieved contribution and finally thesis structure.

- Chapter Two: this chapter provides Introduction to Energy Management. It highlights the definition of energy management, its benefits, standards and barriers to energy efficiency will be considered.

- Chapter Three: this chapter focus on Energy Consumption in Health care Sector. It covers energy consumption in different countries; then, it discussed is discusses the factors influence in energy consumption in health environment and finally, it reviews on recent researches which focused on saving energy in hospitals.

- Chapter Four: this chapter discusses the followed methodology in the research and explains process of the research. it justifies and criticise the applied methods.

- Chapter Five: this chapter it highlights the findings and results in the research. It covers the results that gained from quantitative data for 5 hospitals and semi-structured interviews with 18 people of top technical managers.

- Chapter Six: this chapter presents the research discussion for gained results and findings. Also, it answers the research questions in this study.

- Chapter Seven: this chapter it draws the main conclusions and provides the recommendations to help in implementing effective energy management programs in hospitals in Saudi Arabia. Finally, it illustrates research limitations and offers recommendations for future work.

1.7 List of Publications

- Alhurayess, S. and Darwish, M.K. (2012) 'Analysis of energy management in hospitals', *Universities Power Engineering Conference (UPEC), 2012 47th International*. IEEE, 1-4.
- S. Alhurayess, M.K. Darwish, 'Analysis of energy management in hospitals', *Research Student Conference (ResCon), School of Engineering and Design, Brunel University.2012*
- S. Alhurayess, M.K. Darwish, 'Analysis of energy management in hospitals', *Research Student Conference (ResCon), School of Engineering and Design, Brunel University.2013*

Chapter 2: Introduction to Energy Management

2.1 Introduction

Following the introduction chapter, this is the first part in the literature review. This chapter provides a brief background to energy management by giving the definition of energy management and energy management matrix; then, it highlights benefits that come from implementing energy management and energy management standards will be covered. Barriers to energy efficiency and their classifications will be discussed.

2.2 Background to Energy Management

Turner and Capehart state that while energy management has different meanings, it can be defined as "The judicious and effective use of energy to maximize profits (minimize costs) and enhance competitive positions" (Turner *et al.*, 2006). Based on this definition, energy management's primary objective is maximising profits and reducing costs. Also, there are desirable sub-objectives for energy management, such as:

1- To improve energy efficiency and reduce energy use to reduce costs
2- To cultivate good communication concerning energy matters
3- To develop and maintain effective monitoring, reporting and management strategies for wise energy use
4- To find new and better ways, through research and development, to increase returns from energy investments
5- To develop employee interest in, and commitment to, the energy management programme
6- To reduce the impact of curtailments, brownouts or any interruption to the energy supply.

In addition, many operations, from product to design and shipment, can be covered by the definition of energy management (Turner *et al.*, 2006). Moreover, any energy management programme has certain requirements that will need to be in place. An energy management programme should fulfil these requirements

- Establish a plan for energy management.
- Establish records for energy.
- Identify outside assistance required.
- Assess future energy needs.
- Identify sources of finance.
- Make recommendations for energy.
- Implement recommendations.
- Provide liaison for the energy committee.
- Plan strategies for communication.
- Evaluate the effectiveness of the programme (Hansen, 2006).

These requirements require the energy management team, including the energy manager, to have specific skills for the implementation of an energy management programme. These skills are defined as follows:

- The team should have enough technical knowledge within the group to either understand the technology used by the organisation, or to be trainable in that technology.
- The team should have an understanding of any potential new technology that can be appropriate to the programme.
- The team should have planning skills that will help to establish the organisational structure, determine educational needs, plan energy surveys and an energy management plan, and develop a strategic energy management plan.
- The team should have the ability to understand the economic evaluation system used by their organisation, especially payback and life cycle cost analysis.
- The team should have good communication and motivational skills, and everyone within the organisation should be involved in energy management (Turner *et al.*, 2006).

2.2.4 The Energy Matrix

The Energy Management Matrix has been devised to: 1) assist with identifying and describing the current level of sophistication of different aspects of energy management in an organisation; and 2) assist with organising an energy management strategy. The Matrix provides an efficient, easy to use and effective method of establishing an organisational profile (The Australian Energy Efficiency Exchange website, 2014) and (Gir, 1993).

2.2.4.1 How to Use the Energy Management Matrix

In order to establish an organisational profile, each column needs to be considered individually. The individual completing the matrix places a mark in each column to indicate where they think the company is currently located (this can be within or between cells, depending on which is considered to be more accurate).

The organisational profile is determined by joining the marks across the columns. This will describe the organisation's approach to energy management, and provide an overall indication of how well-balanced energy management is within the organisation.

Level 0

At this level, it is fair to say that energy management is not on the organisation's agenda.

Level 1

The organisation's energy management situation starts to improve.

Level 2

Energy management is acknowledged as important by senior management but, in practice, there is little active commitment or support for energy management activities.

Level 3

Senior managers acknowledge the value of an energy reduction programme.

Level 4

Energy consumption is a major priority throughout the organisation.

As stated by (The Australian Energy Efficiency Exchange website, 2014) and (Gir, 1993).

Table 2-1: Energy Matrix (Source: Energy Management Guide: Organisational Aspects of Energy Management, GIR 12, BRECSU,1993)

LEVEL	ENERGY POLICY	ORGANISATION	MOTIVATION	INFORMATION SYSTEMS	PROMOTION	INVESTMENT
4	Energy policy, action plan and regular review have commitment of top management as part of a corporate strategy	Energy management is fully integrated into management structure. Clear delegation of responsibility for energy consumption	Formal and informal channels of communication regularly exploited by energy manager and energy staff at all levels	Comprehensive system sets targets, monitors consumption, identifies faults, quantifies savings and provides budget tracking	Marketing the value of energy efficiency and the performance of energy management both within the organisation and outside it	Positive discrimination in favour of 'green' schemes with detailed investment appraisal of all new-build and refurbishment opportunities
3	Formal energy policy but no active commitment from top management	Energy manager accountable to energy committee representing all users, chaired by a member of the managing board	Energy committee used as main channel together with direct contact with major users	Monitoring and targeting reports for individual premises based on sub-metering/monitoring, but savings not reported effectively to users	Programme of staff training, awareness and regular publicity campaigns	Same payback criteria employed as for all other investment. Cursory appraisal of new building and refurbishment opportunities
2	Unadopted energy policy set by energy manager or senior departmental manager	Energy manager in post, reporting to ad-hoc committee, but line management and authority unclear	Contact with major users though ad-hoc committee chaired by senior departmental manager	Monitoring and targeting reports based on supply meter data. Energy unit has ad-hoc involvement in budget setting	Some ad-hoc staff awareness and training	Investment using short-term payback criteria only
1	An unwritten set of guidelines	Energy management is the part-time responsibility of someone with only limited authority or influence	Informal contacts between engineer and a few users	Cost reporting based on invoice data. Engineer compiles reports for internal use within technical department	Informal contacts to promote energy efficiency	Only low-cost measures taken
0	No explicit policy	No energy management or any delegation of responsibility for energy consumption	No contact with users	No information system. No accounting for energy consumption	No promotion of energy efficiency	No investment in increasing energy efficiency in premises

2.3 Benefits of Energy Management

In this section, the benefits of energy management are covered in detail. These benefits are categorised into three groups: economic, environmental, and social and health benefits.

2.3.1 Economical Benefits of Energy Management

Energy and energy systems have a strong impact on social and economic development and humanity on all scales – at household, community, regional and national levels (Worrell, 2001). In industry, many improvements can be achieved from energy efficiency, such as enhanced competitiveness at the global level, and safety and job satisfaction at the individual level. These are only a few examples from the 224 different "non-energy benefits" that Worrell and others reported after examining the relationship between productivity and energy efficiency improvement in industry. Furthermore, the financial impacts of energy efficiency are reduced costs of generating energy, after increasing capacity by establishing more energy plants, and avoiding potential problems that may come with infrastructure and planning. Energy efficiency can help to reduce blackouts and other costs that come from shortfalls in power, which will help to meet the estimated 4.7% increase in global primary energy demand, reported by the IEA (IEA, 2011c). Another benefit is increasing asset values, as the United States Environmental Protection Agency (US EPA) reported an estimated increase in asset value of USD 3 for every USD 1 invested in energy efficiency (FYP, 2012). In addition, the reduction in energy bills, prices and costs for industry has led to an increase in production and exports (Barker & Foxton, 2007).

2.3.2 Environmental Benefits for Energy Management

As energy consumption increases, greenhouse gas emissions also increase; thus, by reducing energy consumption, energy efficiency reduces emissions as well. In Europe, energy efficiency is the best method for attaining the important objectives set by the

European Commission in 2008, which focus on reducing GHG-emissions by 20% and reducing energy consumption by 20% on year 2020 (EC, 2008).

2.3.3 Social and Health Benefits for Energy Management

It can be argued that access to high-quality energy resources and technologies can create a chain of demographic, health and development outcomes by changing the relationships (Ezzati *et al.*, 2004). Energy effects on health and public welfare are closely related to energy sources and the types of technology utilised for energy conversion (Hall *et al.*, 2003). Therefore, it can be recognised that energy issues affect society. Even though energy benefits social, economic and public health development, the production process for energy can be detrimental to public health, in both the short- and long-term (Goldemberg, 1985, 2002).

Thus, energy efficiency can solve many social and health problems caused by energy issues. As mentioned previously in this chapter, energy efficiency can benefit consumers by reducing blackouts and other energy-related costs. Also, Wade *et al.* (2000) state that the estimated range for created jobs is 26.6 for every EUR 1 million spent on energy efficiency interventions. With regard to health, energy efficiency can help to reduce carbon emissions in the atmosphere, which may cause many health problems, such as asthma, pulmonary diseases and laryngeal cancer (Bruce, 2000).

2.4 Standards in Energy Management

This section briefly covers energy management standards.

2.4.1 Background on Energy Management Standards

Along with the need for energy management comes the demand for energy management standards. Thus, many energy management standards have been established, such as: DS-INF 136 in Denmark, the EM System Standard IS 393 (2005) in Ireland, and ANSI MES 2000 in the United States. In 2009, the British Standards Institution (BSI) established a standard for energy management called "BS EN 16001:2009, Energy management systems – Requirements with guidance for use" (BSI website). That standard has become one of the most highly considered standards.

By 2008, a new project committee (PC 242 – Energy Management) was approved by the Technical Management Board of International Standards Organisation (ISO) which is based in Geneva. That project was appointed to develop a standard for energy management, and as a result, the International Organization for Standardization (ISO) released a standard for energy management called "ISO 50001:2011, Energy management systems – Requirements with guidance for use" in 2011.

2.4.2 Main Concept of the ISO 50001

ISO 50001 is based on the Plan-Do-Act-Check cycle. Generally, BSI 16001:2009 and ISO 50001:2011 have the same required elements in energy management systems, which are:

1- Establishment of energy policies and responsibilities
2- Energy planning
3- Implementation
4- Checks and evaluations
5- Management review

Table 2-2 illustrates the Plan-Do-Act-Check cycle concept in the Energy Management Standard (50001:2011).

Table 2-2: Energy management concept (Source: ISO 50001:2011)

Element	Explanation
PLAN	Establishment of energy policies and responsibilities Energy planning
DO	Implementation
ACT	Checks and evaluations
CHECK	Management review

Figure 2-1 shows the model of Energy Management Standard (ISO 50001:2011) which illustrates the main framework for that standard.

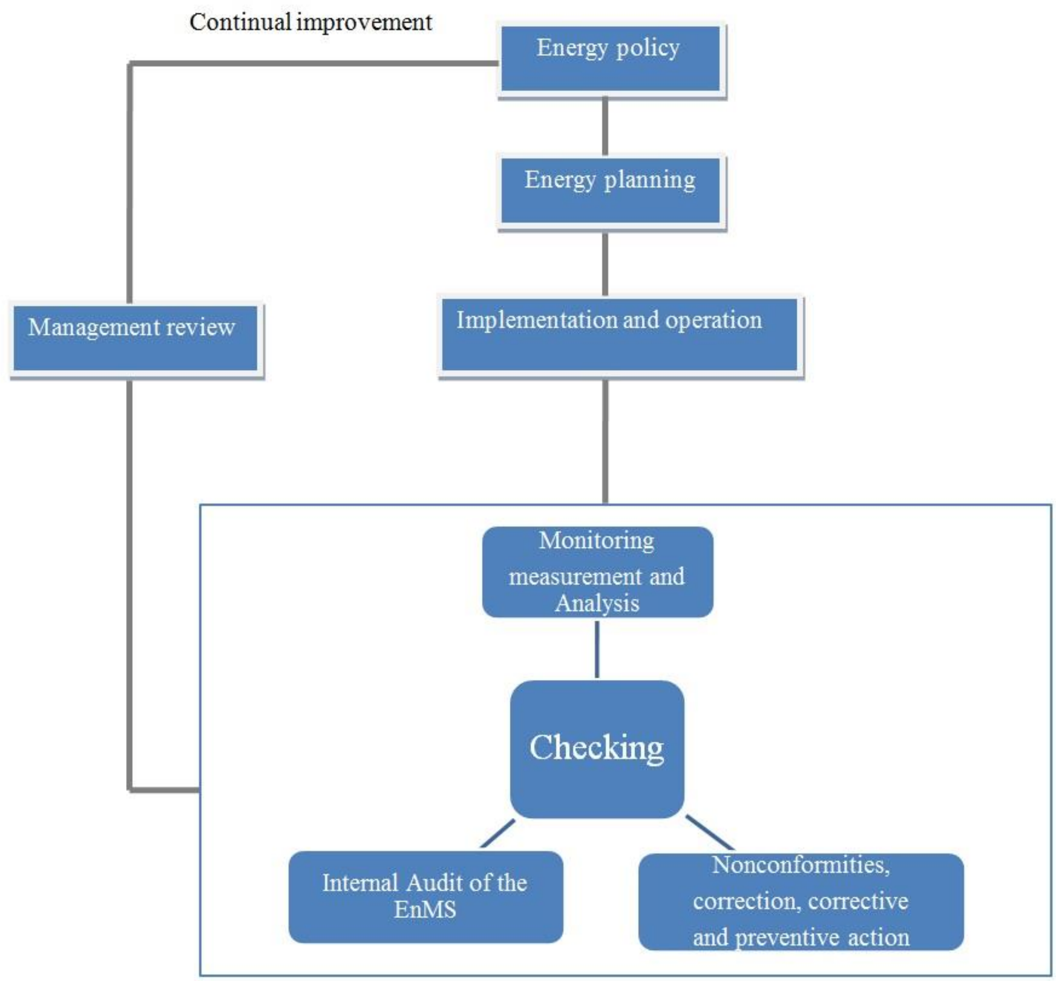

Figure 2-1: Energy management system model for both standards. (Source: ISO 50001:2011 and modified by the researcher)

There are some differences between these two standards. Generally, ISO 50001 has more requirements; for example, ISO 50001 contains procedures for the control of documents and internal communication. Also, ISO has introduced new concepts, such as Boundaries and Energy Services.

2.4.3 Features of ISO 50001

Some of the clauses in ISO 50001 mean that this standard has many advantages compared to BSI 16001:2009. The changes in ISO 50001 can be summarised as follows:

- It refers to continual improvement of energy performance, including energy efficiency, energy use and consumption.
- ISO 50001 terms and definitions include new definitions for boundaries, correction, energy baseline, energy management team, energy review, energy services, scope and significant energy use.
- Regarding the internal audit of the Energy Management System, ISO 50001 has removed the following requirement: "The management responsible for the area being audited shall ensure that actions are taken without undue delay... etc."
- ISO 50001 clearly specifies the role of top management.
- Regarding the energy policy, the requirement that the policy shall define the scope and boundaries of the energy management system is not required in ISO 50001.

2.4.4 Benefits of ISO 50001 in Healthcare

As enterprises continue to implement energy management programmes, they are helping to establish a common energy management standard. A review of presently applied energy management standards reveals that the BSI 16001:2009 and ISO 50001:2011 are the most popular standards. These standards are popular, because any hospital or medical organisation, regardless of its size or type, can implement them. They are flexible, because they are not technical standards and are suitable for all types of energy. Instead, they are general and not complicated, so they are easy to understand and implement. They are even flexible enough to be implemented in both developing and developed countries and a variety of environments. Moreover, the ISO 50001:2011 is the most updated and most recently published standard in energy management. It covers many details and introduces many modified and new definitions and concepts, such as energy services and boundaries, so the ISO 50001:2011 appears to be the more reliable and dependable standard. For establishing an energy management programme in a field where energy efficiency has become a low priority, such as healthcare, the managers recommends implementing the ISO 50001:2011, because this standard has the additional incentive of reducing the organisation's costs.

The concept for the ISO 50001:2011 requirements (Plan – Do – Act – Check) allows for more revising than does the BSI 16001:2009, so hospitals and medical centres could always improve their management programmes with the newer standard. The concept not only helps the health organisations to implement the programme but also allows non-technical professionals to share the responsibilities and the commitment to energy efficiency in health environment. Through a planning process for energy management, the hospitals should establish a team and clarify the definition of energy within the context of the organisation, including the energy's boundaries and its physical and organisational limits. If managers, in health environment, use the planning process, then they can merge energy management objectives inside the organisation's culture with outside objectives by demanding a commitment from the top management to energy management. Every energy management programme's target is to reduce costs and energy use, but, before the programme can achieve that, all departments must communicate clearly and sufficiently while implementing and reviewing the programme and its outcomes to increase non-technical professional contribution to the programme, such as contributions from financial and IT departments. Fortunately, the ISO standard is written in a language that can be understood by non-technical professionals.

2.5 Barriers to Energy Efficiency

This section focuses on barriers to energy efficiency in details.

2.5.1 Background on Energy Efficiency Barriers

Energy efficiency is one of the most important issues when implementing an energy management programme in any organisation. This section covers recent classifications of barriers to energy efficiency; this is also important to guide the researcher to achieve one of the research objectives, which is exploring barriers to energy efficiency in hospitals.

2.5.2 Classification of Barriers to Energy Efficiency

As defined by Sorrell *et al.* (2000), a barrier is a "postulated mechanism that inhibits investment in technologies that are both energy efficient and (apparently) economically efficient". It is necessary to comprehensively categorise the barriers to energy efficiency in taxonomy in order to obtain a complete image of the complex problem. This will allow for a more effective integration of barriers into models and it will allow organisations to formulate more in-depth and rational policy responses to reduce the effect of these barriers, as emphasised by Fleiter *et al.* (2011). As a great scientific debate, Sorrell has classified the barriers to energy efficiency into main three groups:

1. Economic
2. Behavioural
3. Organisational

Table 2-3 shows Sorrell's classification for barriers and gives examples for each group. Furthermore, Table 2-4 shows Sorrell's taxonomy of barriers to energy efficiency in greater detail.

Table 2- 3: Sorrell's classification of barriers

Perspective	Example	Actors	Theory
Economic	Imperfect information, asymmetric information, hidden costs, risk	Individual and organisations conceived of as rational and utility maximising	Neo-classical economics
Behavioural	Inability to process information, forms of information, trust, inertia	Individuals conceived of as boundedly rational with non-financial motives and a variety of social influences	Transaction costs, economics, psychology, decision theory
Organisational	Energy managers lack power and influence; organisational culture leads to neglect of energy/environmental issues	Organisations conceived of as social systems influenced by goals, routine, culture, power structures, etc.	Organisational theory

Table 2- 4: Sorrell's classification of barriers

Perspective	Sub-division	Barrier	Description
Economic	Rational Behaviour	Heterogeneity	Technology may not be cost-effective in a particular instance
		Hidden costs	Technology investment entails extra costs or loss of benefits that are not reflected in engineering models
		Risk	Stringent investment criteria may represent a rational response to risk
		Access to capital	Some agents cannot obtain capital to invest
	Market or organisational failure	Imperfect information	Agents lack sufficient information to make economically efficient decisions
		Adverse selection	Agent cannot transmit or discover energy properties of a good
		Split incentives	Agent cannot appropriate benefit of investment – landlord-tenant type relationships
		Principal-agent relationships	Principal may impose strict investment criteria to compensate for imperfect information

Behavioural	Bounded Rationality	Bounded rationality	Cognitive limitations lead to agents satisficing rather than optimising and relying on routines & rules of thumb. Organisational routines may systematically neglect energy efficiency
	The human dimension	Form of information	Form of information may be inadequate and unable to stimulate action
		Credibility and trust	Agent may not trust source of information
		Inertia	Agents resist change because they are committed to what they are doing and justify inertia by downgrading contrary information
		Values	Lack of environmental awareness leads to neglect of efficiency opportunities
Organisational theory		Power	Agents lack sufficient power within an organisation to initiate action
		Culture	Environmental awareness and energy efficiency play no part in corporate culture

This classification is called Sorrell's Taxonomy, and it has become the base for classifying barriers to energy.

Before that, Webar categorised barriers using the following typology:

- Institutional barriers: caused by political institutions, such as local authorities.
- Obstacles conditioned by the markets: e.g. market failure.
- Organisational barriers: barriers inside the organisation.
- Behavioural barriers: barriers inside individuals (Webar, 1997).

Also, he states that barriers cannot be empirically classified due to their invisibility, and that therefore his classification of barriers was derived from other studies that investigated obstacles (Webar, 1997). The question of what leads to barriers to energy efficiency had been investigated widely before Webar. For example, in 1978, York *et al.* focused on issues related to energy conservation and more general topics of barriers, in order to solve implementation problems and encourage innovation.

In 1980, a systematic study was performed by Blumstein *et al.* In that study, the barriers were separated into six categories:

1. Misplaced incentives: the person who is trying to save energy does not always acquire the economic benefits of energy conservation.
2. Lack of information: adequate information is essential.
3. Regulations: it is difficult or impossible to implement a cost-effective measure if there are conflicts between the existing codes or standards.
4. Market structure: although a measure or device for energy conservation is cost-effective, it may not be available on the market.
5. Financing energy: energy conservation may require an initial investment, which may require capital.
6. Custom: it is possible that the consumer may reject the conservation measure.

By studying research on energy efficiency, it can be observed that the terms "energy efficiency gap" or "energy paradox" – which refer to the existence of a gap between potential cost-effective energy efficiency measures and measures actually implemented – highlight barriers to energy efficiency (York *et al.*, 1978; Blumstein *et al.*, 1980; Stern & Aronsson, 1984; Hirst & Brown, 1990; DeCanio, 1993; Jaffe & Stavins 1994; Weber,1997; Sorrell *et al.*, 2000; Brown, 2001; Schleich, 2004;Sorrell *et al.*, 2004; Schleich & Gruber, 2008). Furthermore, these theoretical studies provided empirical results regarding barriers to energy efficiency in industry. For example, Sardianou (2008) provided a contribution to barriers to energy efficiency and investment in Greece. Also, Schleich has made comparisons between the commercial and service sectors in Germany (Schleich, 2009). A new study, conducted by Trianni and Cagno (2012), made an introductory analysis of the barriers in Italian non-energy intensive small and medium-sized manufacturing enterprises to provide several insights into the relationships between operational barriers. Also, Rohdin *et al.* (2007) provided a relevant empirical contribution by trying to describe the relationship between operational and theoretical barriers, depending on Sorrell's taxonomy provided by and applied to the study of Swedish foundries.

Establishing an energy management and energy efficiency programme can be challenging for a variety of reasons. Many studies have discussed these energy efficiency barriers, noting some differences between the number and type of classification groups of barriers. In addition, categorising the barriers into different groups would make a huge contribution to the science by giving companies a quick reference guide that they can use to discover the barriers within their organisation and to remove or reduce the negative impact of them. These differences can be observed by merging one barrier group with other barrier groups or by giving a barrier its own group. Generally, Sorrell's taxonomy, which classifies barriers into the three perspectives of economic, behavioural, and organisational, is the most frequently recommended in the literature.

By focusing on the barriers to energy efficiency, researchers have been investigating and exploring barriers to energy efficiency in the industrial environment. Few studies have focused on other fields, so other industries need further investigation. Moreover, many of these studies are theoretical, and few have empirically discussed energy efficiency barriers. Thus, the demand for a new taxonomy of energy efficiency in other fields, such as healthcare, can be recognised. The new taxonomy should consider the characteristics of those environments. In addition, studies have also been conducted in developed countries and energy efficiency is an important issue for developing countries also, so exploring and investigating the barriers to implementing energy efficiency programmes in developing countries is of equal urgency. By removing the barriers to energy management and then establishing an energy management programme, organisations can save energy as well as the related costs in the future as well as avoid many problems.

2.6 Summary

Many reports and forecasts are stating that the demand for all types of energy and resources will increase greatly in the future, so the demand for energy management is also increasing. Furthermore, the reports and forecasts demonstrate that the increasing demand also applies to renewable energy. Developing countries as well as developed countries need to practise energy management, such as reducing or optimising their energy consumption. By optimising their production operations from product design to product shipment, organisations can reduce their energy consumption and costs and improve their energy efficiency. Energy management offers many other benefits, such as enhancing the competiveness of the global energy market, attracting investments to this market, and raising the individual’s job satisfaction. Energy management is a major factor in finding the solutions to reducing the greenhouse gas emissions that cause many problems for public health and the environment by optimising energy use and finding opportunities for green and clean resources of energy. Therefore, energy management helps far more than the economy: it can improve demographics, social life, and public health.

To conclude, this chapter covered energy management definition, benefits of implementing energy management programme including economically, environmentally, socially and healthy. Also, it covered barriers to implement energy management and energy efficiency in organisations. Furthermore, Next chapter will cover in details energy consumption rates in healthcare sector in many countries, energy types which are used, and the factors affect in energy consumption.

Chapter 3: Energy Consumption in Health care Sector

3.1 Introduction:

The research aims to analyse energy management programme performance and find opportunities to reduce costs and energy consumption in hospitals. In order to achieve that, the barriers to energy efficiency were discussed and the motivations for energy saving were investigated in the previous chapter. Also, energy management standards were covered in detail. Furthermore, energy consumption, the type of consumed energy and activities in the health environment should be analysed and discussed in order to find opportunities for saving energy. In this chapter, energy consumption in different countries is analysed and discussed, followed by the factors that influence energy consumption in the health environment. At the end of this chapter, recent research studies that focused on saving energy in hospitals are reviewed. Figure 3-1 shows the structure of literature review in that conduct in this research.

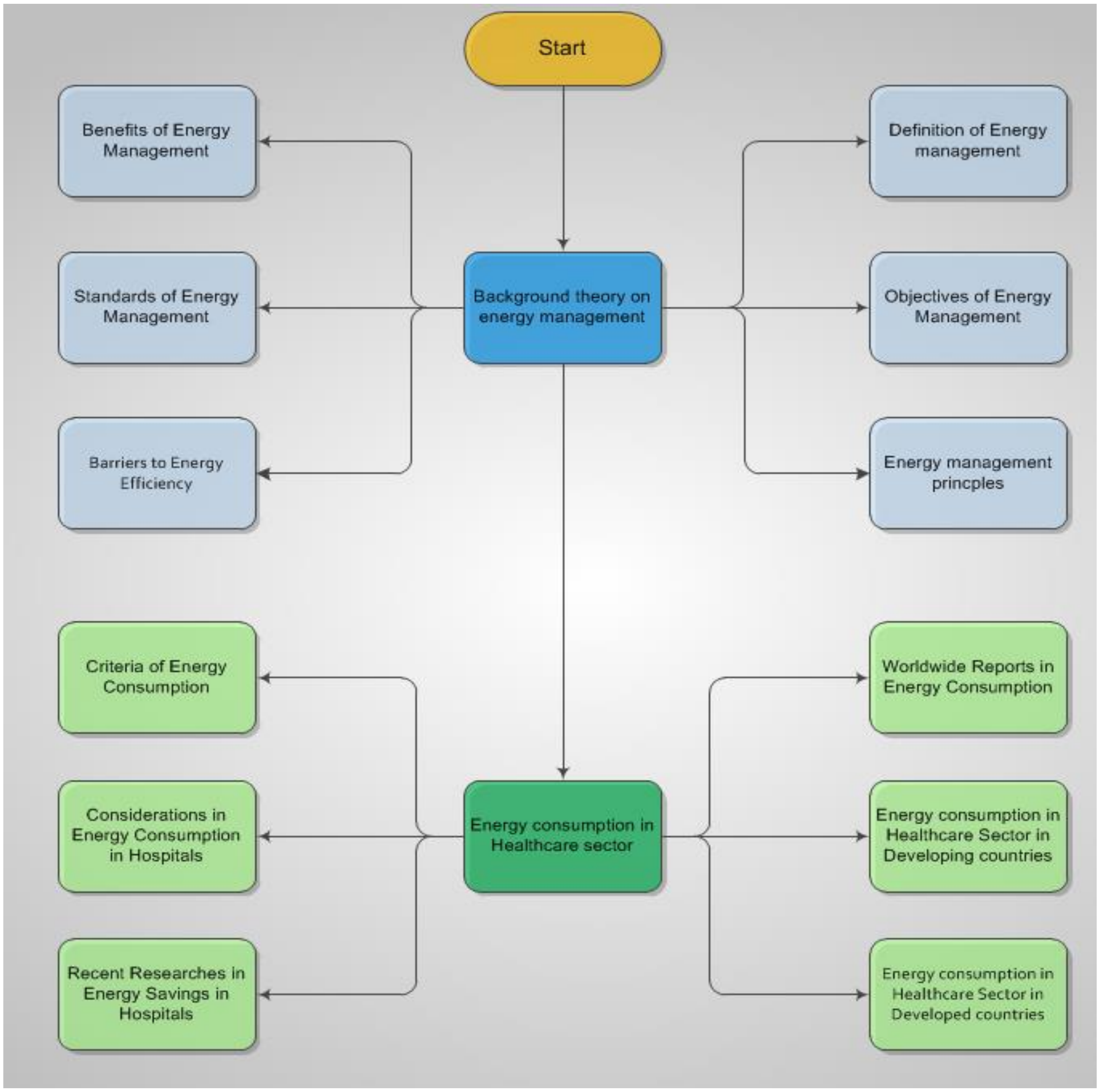

Figure 3-1: The structure of literature review in this research

3.2 Worldwide Reports of Energy Consumption

In recent years, energy consumption has increased in many countries throughout the world. According to the 2011 British Petroleum Statistical Review of World Energy (issued in June 2012), global primary energy consumption grew by 2.5%, approximately in line with the average of the previous 10 years. Also, 71% of global energy consumption growth was represented by China alone (British Petroleum Statistical

Review, 2012). In the United Kingdom, energy consumption in 2011 was 7% higher than in 2010, according to the Department of Energy and Climate Change (ECC Report, 2012). Furthermore, the European Commission Directorate General for Energy and Transport (2008) reported that primary energy consumption in 2030 will exceed the consumption reported in 2005 by 11%. The Energy International Agency (2008), who predicted the average increase to be near 1.8% annually between 2006 and 2030, also argued that the total energy demand will be nearly 16% higher in 2015 than it was 2006. In Saudi Arabia, the Ministry of Economy and Planning estimated an increase in electric power consumption from 2005 to 2008, with 5.8% as the annual average rate, compared to the 4.9% target set by the eighth plan (MEP 9th Plan Report, 2010).

3.2.1 Energy Consumption in Health Care Sector

In the European Union, energy consumption by residential and public buildings represents over 40% of the total energy that is used by all of the member countries (Directorate General for Energy and Transport, European Commission, 2009). Furthermore, estimates indicate that the EU will be importing 67% of its energy by 2020 (Van Der Linde, 2004). In addition, energy use in commercial and residential buildings has steadily increased by 20% to 40% in developed countries over the last decade (Pérez-Lombard *et al.,* 2008). In Saudi Arabia, peak loads reached approximately 24 GW in 2001, which is 25 times larger than the load levels in 1975. In addition, the loads are expected to reach 60 GW in 2023 (Annual Report for Ministry of Industry and Electricity, 2001). To meet this massive demand, a total investment of over $90 billion will be required (Al-Ajlan *et al.,* 2006).

In China, Yang *et al.* (2008) reported that energy consumption in office buildings reached 70 to 300 kWh/m^2 per year, which is 10 to 20 times larger than the energy consumption of residential buildings. Saidur (2009) reported that approximately 32% of the total energy consumption in Malaysia comes from commercial sector accounts (Saidur, 2009). Also, Saidur *et al.* (2010) reported that electrical motors consume approximately 31-75%

of the total energy in a few selected countries around the world. The estimated energy consumption for hospitals was about 19,311 MWh for 2008 (Saidur, 2010).

The demand on energy increases every day; indeed, population growth, increasing industrial output, and a rapid expansion of wealth in growing economies, such as China and India, have resulted in a huge consumption of energy. Therefore, energy management has become an increasingly important issue throughout recent years. Furthermore, energy management offers many environmental, economic, and social benefits.

Hospitals represent a major sector that relies on a stable energy supply and consumes a lot of energy; therefore, such institutions need to apply energy management strategies to their systems. This chapter discuss energy consumption in hospitals, and major factors in implementing energy management in the health care environment. Finally, it provides a brief review of certain studies focused on energy consumption and evaluating energy technologies in hospitals, and it summarises their findings.

Understanding the energy consumption in hospitals and categorising it into groups can help to reveal which facilities and activities affect the use of energy in hospitals. Also, it helps to find opportunities to optimise and save energy. However, the breakdown of energy consumption in the health care sector can vary from one country to another due to differences in climate, and other issues such as adopted technologies and the rules and regulations that need to be followed. In this chapter, the breakdown of energy consumption in the health care sector is examined in the USA, the UK, Saudi Arabia and developing countries. The reason for selecting these countries is the differences between these countries in terms of climate, adopted technologies, and rules and regulations concerning energy use.

3.2.1.1 Energy Consumption in Health Sector in the US

The 2003 Commercial Building Energy Consumption Survey (CBECS) reported that large hospitals (over 200,000 square feet) in the US accounted for less than 1% of all buildings in the commercial sector and 2% of commercial floor space. However, they consumed 4.3% of the total delivered energy used in the commercial sector in 2003. Similarly, CBECS 2006 reported that 4% of the total energy consumed in the US was consumed by health care facilities (US EIA, 2006). Furthermore, the 2007 CBECS showed that energy consumption increased to reach 5.5% of the total energy used by the commercial sector in 2007 (US EIA website, 2012). In addition, around 7% of electricity consumption in all commercial buildings in 2003 was by health care buildings, as reported by the Annual Energy Review 2009 (US EIA, 2010). By using 836 trillion BTUs of the energy every year, and having more than two and half times the energy intensity and carbon dioxide emissions than those that come from commercial building, hospitals can be estimated to be producing CO_2 emission of more than 30 pounds/square feet, as reported by the US Department of Energy (US DOE, 2009). Also, the World Health Organization has reported that use of electricity in the health sector in the US adds over $600 million annually as direct health costs, and over $5 billion as indirect costs (WHO, 2009).

Furthermore, for operating air conditioning equipment in hospitals, it has been reported that 92% of the supplied energy came from electricity. On the other hand, natural gas, commonly used for heating, accounted for 74% of the total supplied energy in health care facilities. In addition, it was reported that all health care heating depends on natural gas, while fuel oil is only used as an energy source for electricity generation (US EIA website, 2012).

Moreover, lighting is the highest consumer of electricity, according to Figure 3-2 (Annual Energy Review-US EIA, 2009), but it is the 3rd highest consumer of energy as illustrated in Figure 3-3, with water heating being the largest consumer of energy. Also, it has been reported that ventilation and cooling consume a huge amount of electricity in the health care sector.

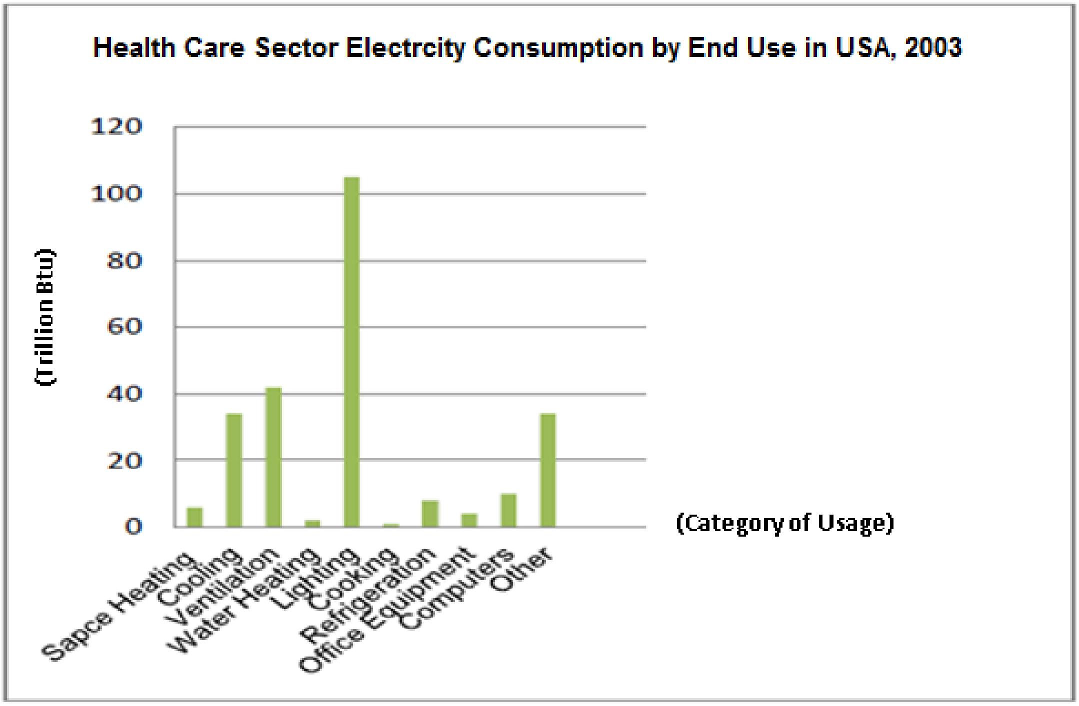

Figure 3-2: Energy use in large hospitals in US and the type of energy.

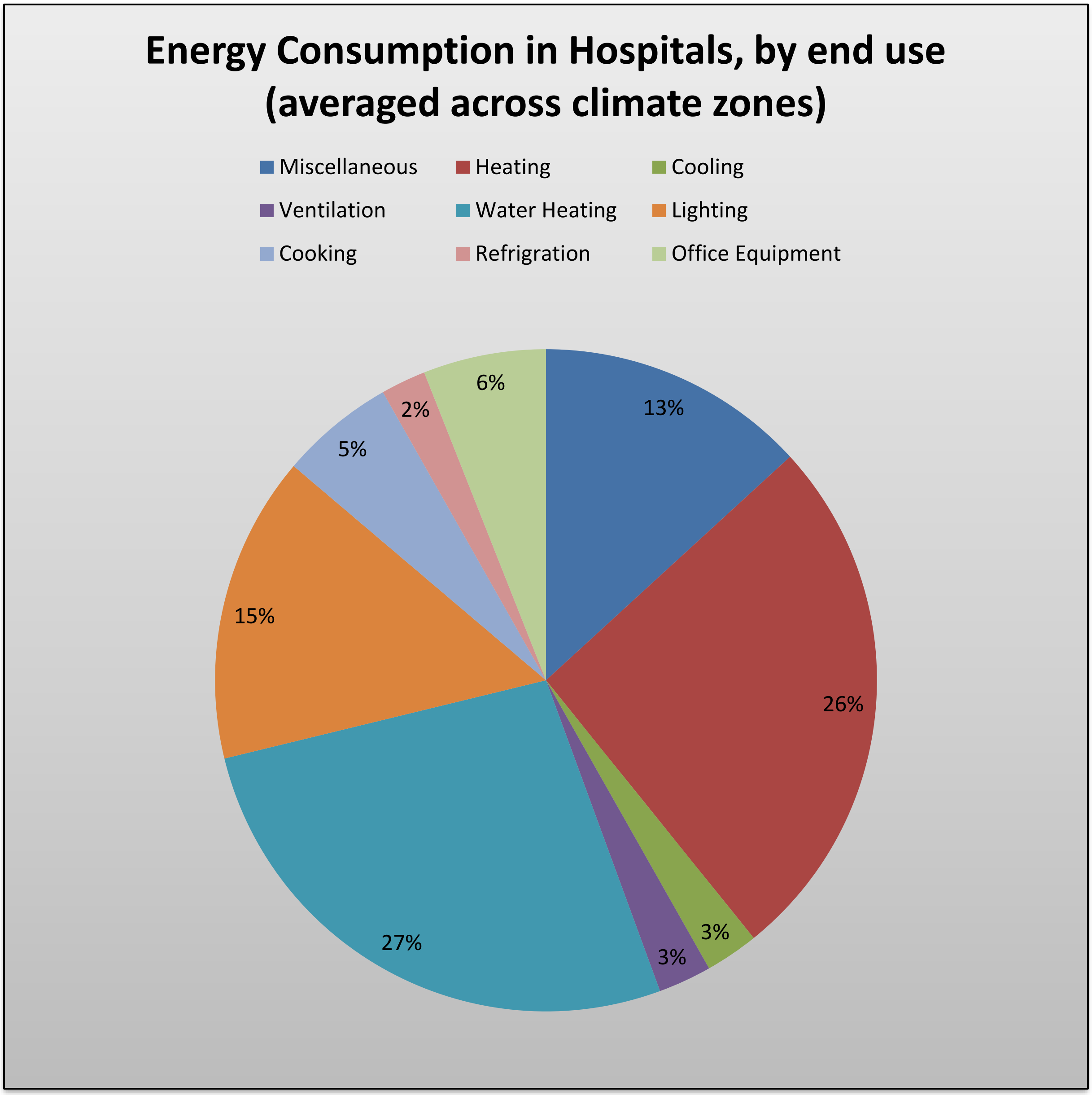

Figure 3-3: Energy use in Hospitals by averaged across climate zones. (Source: Consortium for Energy Efficiency website, 2012)

3.2.1.2 Energy Consumption in Health Sector in the United Kingdom

In the UK, the service sector has consumed 17,168 thousand tonnes of oil equivalent, which represents 12% of the total consumed energy in 2011, according to the Department of Energy and Climate Change in 2012 (UK DECC website, 2012). Moreover, the service sector can be divided into public administration, commercial, agriculture and miscellaneous. Public administration represents 30% of the energy consumption in the service sector, and the health sector is categorised under public administration. As can be seen from Figure 3-4, the health care sector consumed 7% of the total consumed energy of the service sector (UK DECC website, 2012).

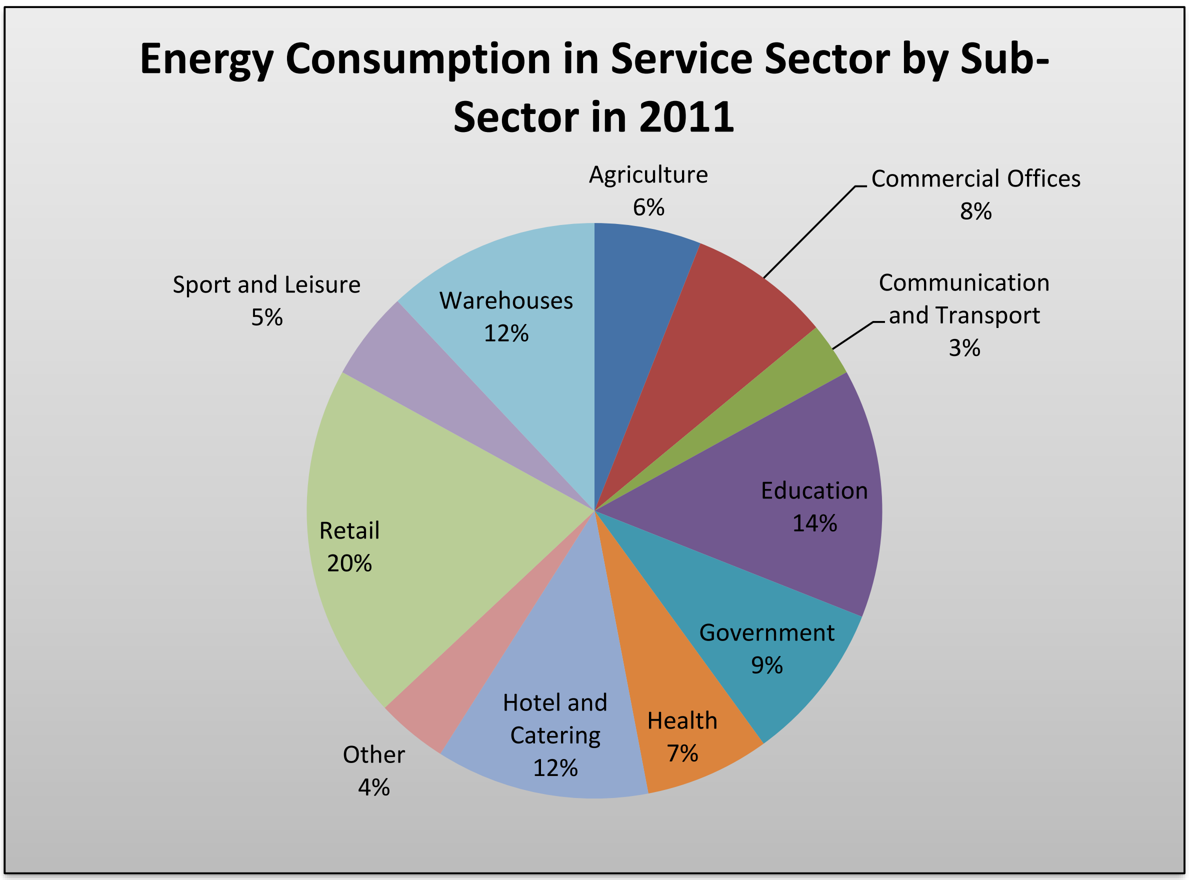

Figure 3-4: Energy consumption in the UK service sector by sub-sectors in 2011 (UK DECC website, 2012).

According to the Department of Trade and Industry and Department for Business, Energy and Industrial Strategy in the official government website in the UK, heating and lighting are the highest consumers of energy consumption in the service sector, followed by hot water and catering, as shown in Figure 3-5 and Figure 3-6.

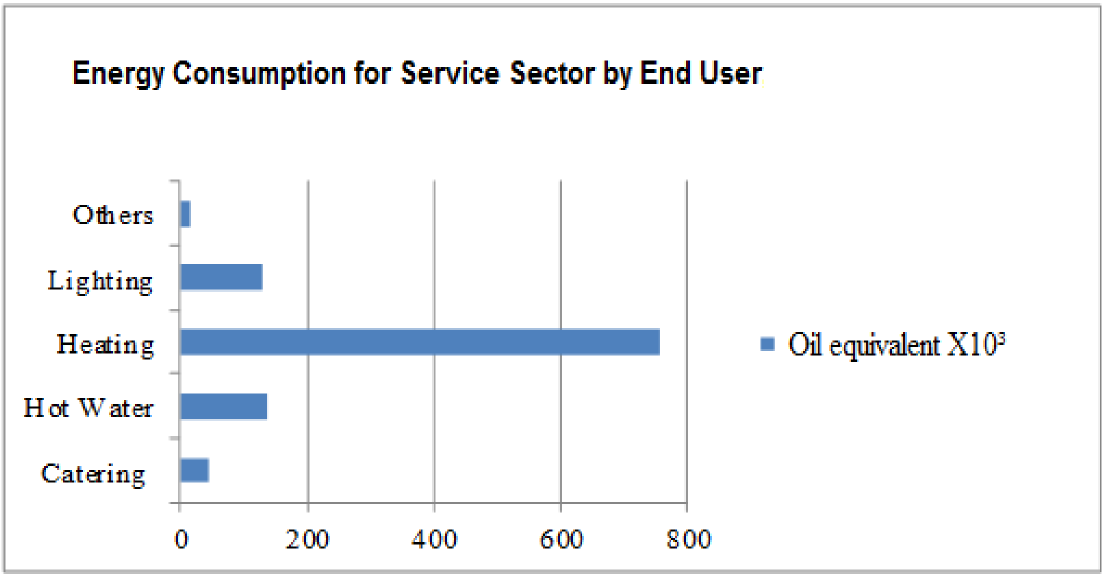

Figure 3-5: Energy consumption in The UK (Source: Department of Trade and Industry, 2012)

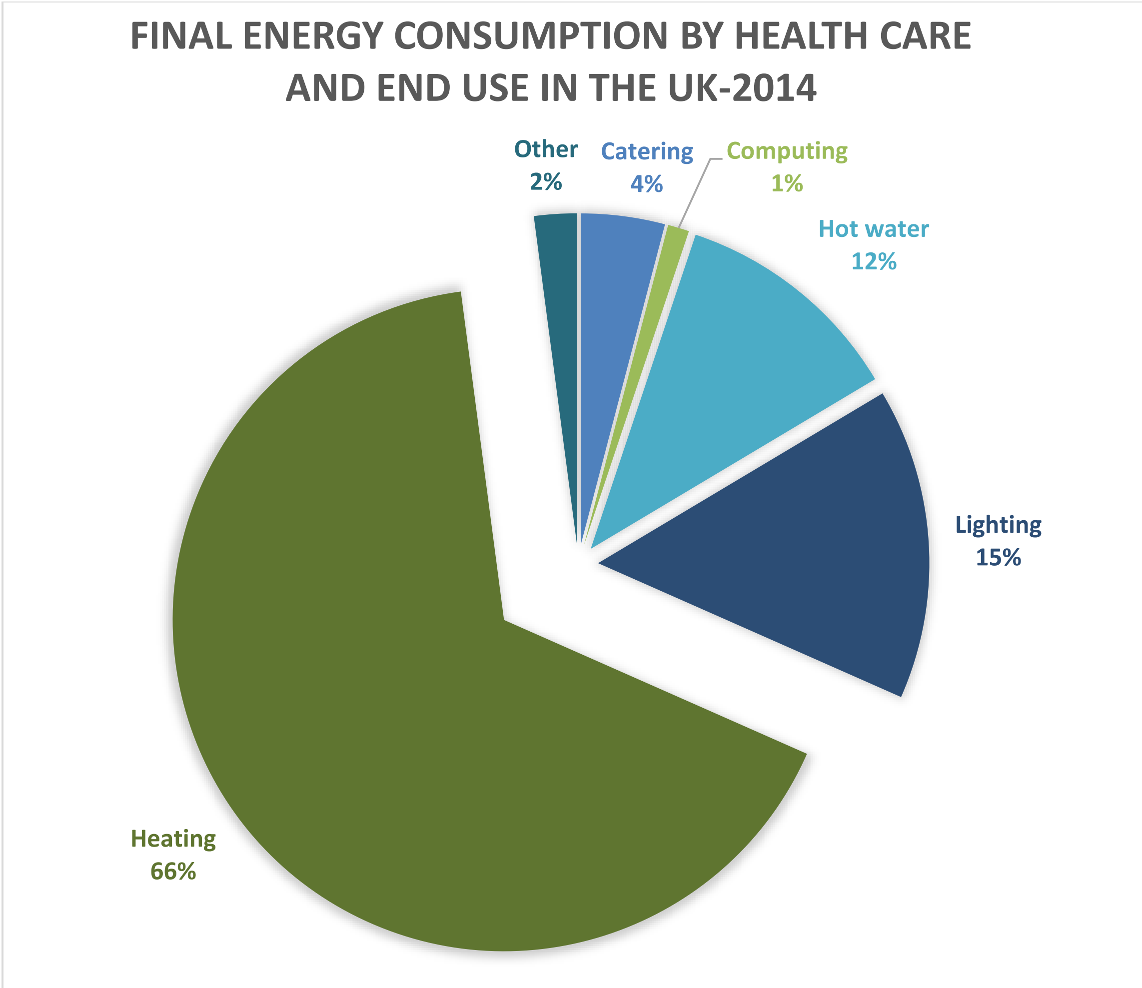

Fig 3-6: Final Energy Consumption by health care and end use in the UK-2014 (Department for Business, Energy & Industrial Strategy - GOV UK website, 2014)

3.2.1.3 Energy Consumption in Health Sector in Saudi Arabia and Developing Countries

In Saudi Arabia, it can be observed there are no official reports that show the energy usage in hospitals, but some researchers have carried out research on energy consumption and have determined an approximate energy usage. They have concluded that air conditioning, lighting and appliances (especially medical equipment) in hospitals in Saudi Arabia consume the highest amounts of electrical energy. For example, it is reported that 42% of electrical energy in public and private sectors, including hospitals, in Saudi Arabia is used for appliances, about 38% is used for air conditioning, and 20% is utilised for lighting (Ahmad *et al.*, 1994). Furthermore, energy consumption was calculated in another study that concluded that air conditioning, appliances, and lighting use the most electricity (Dincer *et al.*, 2004). Figure 3-7 shows the typical electrical energy consumption in Petajoule (PJ) in hospitals in Saudi Arabia.

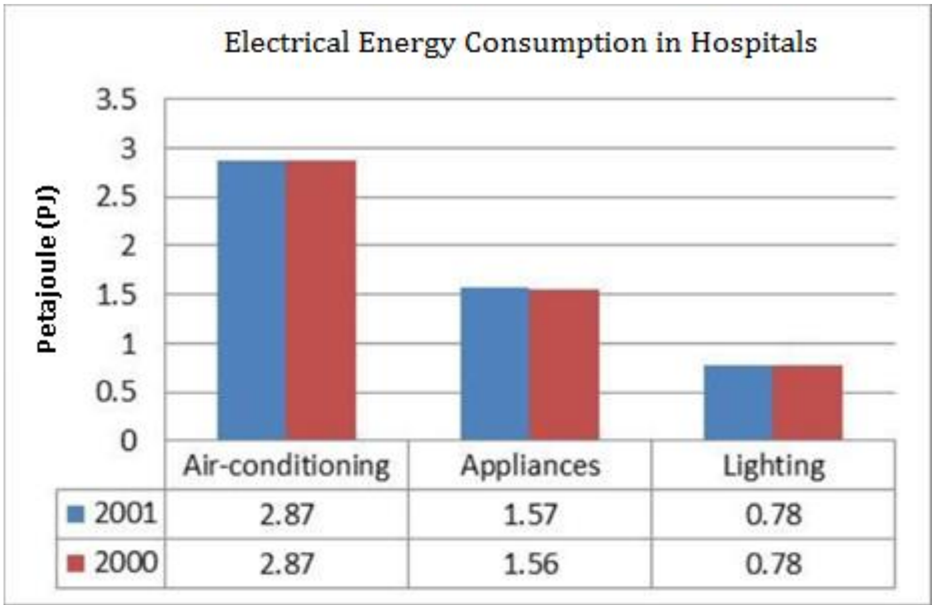

Figure 3-7: Typical electrical energy consumption in Petajoule (PJ) in hospitals in Saudi Arabia.

Saidur *et al.* (2010) conducted a case study in which they analysed the energy consumption of a hospital in Malaysia. They found that the lighting alone consumed the highest amount of energy by 36.3%, followed by biomedical equipment at 34.5% of the total consumption. Figure 3-8 shows all of the categories of energy consumers in this particular hospital (Saidur, 2010).

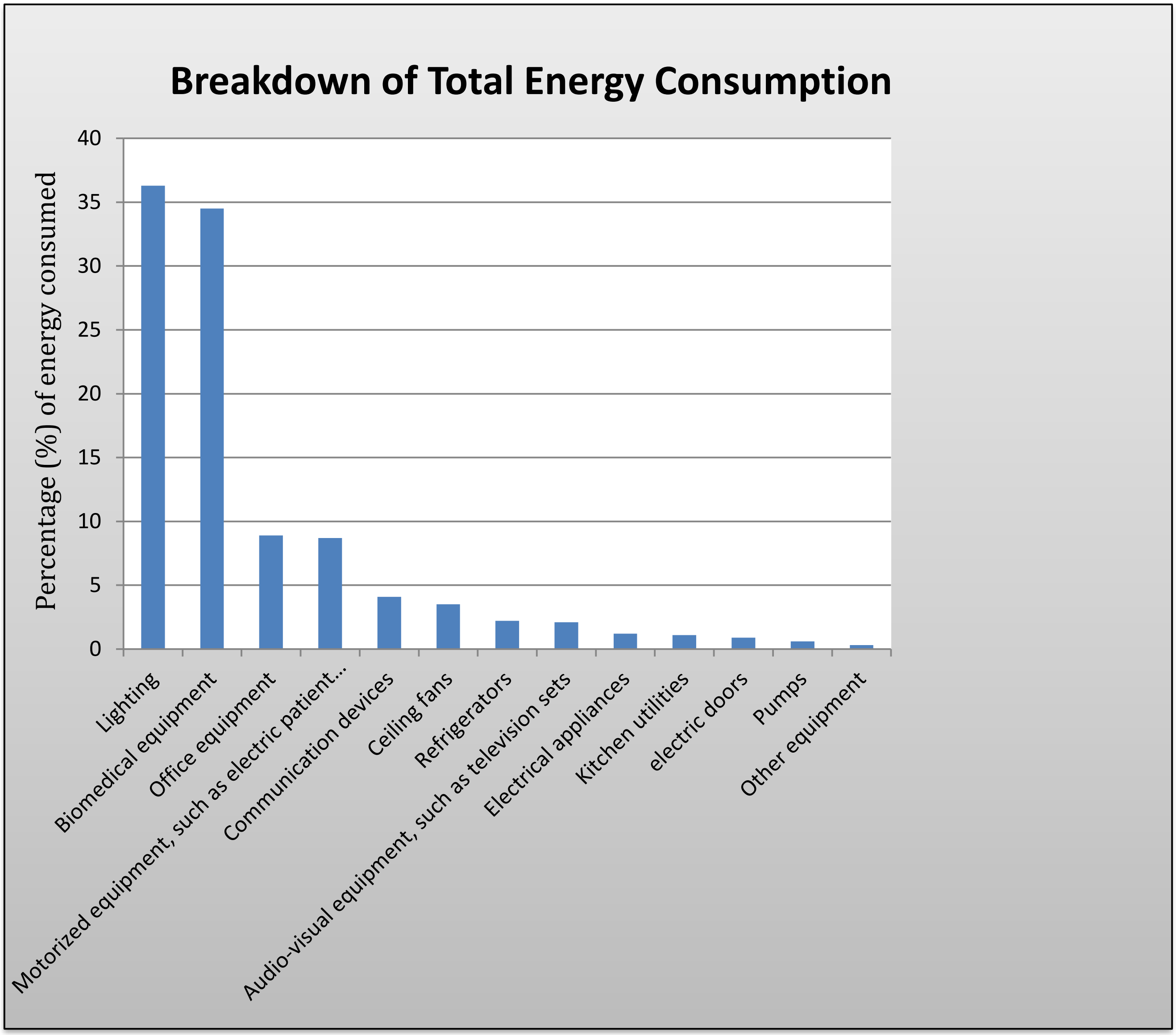

Figure 3-8: Breakdown of the energy consumption by the equipment used in a Malaysian hospital (Saidur, 2010).

3.2.1.4 Important Considerations in Energy Consumption in Hospitals

By studying energy consumption in hospitals over countries it can be observed that there are major factors that can affect consumption and these factors should be considered when designing energy management programmes.

Hospitals can be varied in their types, structures and locations. In addition, they can be categorised into sub-categories according to the level of health services they provide, such as primary health care and secondary health care hospitals. However, many hospitals work 24 hours, 7 days a week, therefore some appliances are not switched off at all. Additionally, for the hospitals' surgical and operating theatres, the maintenance of a proper indoor environment is essential and requires effective and efficient ventilation, heating, and air conditioning systems, which require energy (Dascalaki *et al.*, 2008 and 2009). Also, hospitals are characterised by their large and continuous power demand for medical equipment, a regular heat source required for sanitary processes, and extensive heating and air conditioning requirements, depending on the season and climate (Chinese *et al.,* 2007). These factors should be considered when studying the consumption of energy by hospitals. Furthermore, energy consumption was found to be comparatively low in June because fewer patients were admitted in this month, thereby lowering the amount of energy consumed by biomedical equipment (Saidur *et al.,* 2010). However, in the summer, air conditioning systems require a lot of energy, thereby increasing overall loads. Furthermore, these large seasonal and daily variations in the consumption of electricity are considered technical challenges. In addition, the load increase becomes more concerning when combined with residential and commercial loads in the same region due to extreme weather conditions. This situation intensifies through the daylight hours in the summer as the demand peak load increases with the raising temperatures, thereby causing a drop in output power and efficiency (Al-Ajlan *et al.,* 2006).

Hospital buildings are designed to survive for 50-100 years (Brett *et al.,* 2009) and that means that making any changes in the building is more difficult. In addition, there is high demand for the maximum level of comfort and all the required conditions to help and treat patients (Velimir *et al,2012*). There are also high requirements for air filtration and infection control in medical devices in order to meet the regulations and standards; these results in medical staff and medical device manufacturers giving energy efficiency a low priority.

3.2.1.5 Recent Research on Energy Savings in Hospitals (Technical Solutions and why they may not help)

There are studies introducing technical solutions to find opportunities to save energy in hospitals. Moreover, Bizzarri *et al.* (2004) studied greenhouse gas reduction and primary energy savings in a hospital as well as the use of new technologies, such as fuel cells, photovoltaic systems, and solar thermal systems, as possible effective energy retrofits for hospitals in Italy. They reported that fuel cells seem to be the most promising choice to improve efficiency and save energy (Bizzarri *et al.,* 2004).

Based on the study of the consumption of energy by a hospital in Malaysia, Saidur (2010) found that the hospital consumed approximately 19,311 MWh of energy in 2008. Also, he found that the energy intensity of the hospital was 234 kWh/m^2. Saidur (2010) estimated that 212 MWh, 249 MWh, and 317 MWh of energy could be saved for motor loadings of 50%, 75%, and 100%, respectively. This will translate into monetary savings. He also found that payback periods are less than a year in most situations when high efficiency motors have been implemented. He concluded that nearly 60% of the consumed energy could be saved by using a variable speed drive (Saidur, 2010).

By examining the studies that have discussed energy issues in the health environment, it can be argued that technical solutions can help to improve energy efficiency and save energy. However, the proposed solutions may not be able to be implemented in many countries due to the climate, location and rules and regulations. Furthermore, selecting the type of technologies properly is important for energy conservation and that selection depends on factors such as application type, climate conditions and the requirements of people. Also, public awareness, energy codes, regulations, information and a database of energy are required as supportive tools to achieve energy conservation (Al-Ajlan, 1998). Energy management as a systematic framework and programme can help to save huge amounts of energy in many countries, and may not require complex and difficult changes in the infrastructure.

In many countries, health care sector costs are paid by the government, which makes saving energy a strong challenge. The reason for that is that hospitals are part of the non-profit service sector and the humanity perspective is the main considered issue. Therefore, saving energy can be a complicated issue and requires efforts from specialised and non-specialised people.

3.3 Summary

This chapter focused on energy consumption in the commercial and service sectors, and then in the health sector as a sub-sector. The purpose of this was to achieve one of the research objectives, which is analysing the current energy consumption in many countries, along with type of energy used, and the activities that consume energy in the health environment; this would in turn provide opportunities for saving energy. However, as a huge consumer sector, hospitals are very dependent on stable supplies of power and they are major consumers of energy. The consumption of energy in hospitals can be affected by different factors such as weather, demographic location, policies and regulations. Therefore, the change in consumption rates can vary from country to country due to these factors. Furthermore, there are differences in the applications, activities and type of energy used in hospitals, which may play a role in consumption rates.

The research aims to give recommendations for designing an energy management programme in the health environment. However, implementing energy management in hospitals requires the consideration of many factors. Therefore, this chapter provided in detail the considerations and nature of the health environment before designing an energy management programme. For instance, hospitals are working 24 hours per day and the demand for these working hours is high. Also, the priority given to humanity when providing health services is high, therefore the medical staff and manufacturers give that issue more concern and may not take into account the importance of energy saving opportunities. Moreover, there are challenges in providing the maximum level of comfort and treatment, which requires more energy to achieve. Previous studies show different methods and evaluations for technologies and systems to optimise models that reduce energy consumption rates and CO_2 emissions. These studies have suggested many solutions for saving energy in hospitals. However, these suggested solutions may not be able to be implemented in many countries due to nature of demographic locations, costs and the prescribed rules and policies. Energy conservation requires proper selection of technologies which depends on supportive tools such as public awareness, energy codes, information, and a database for energy. The next chapter will focus on the research methods and techniques that helped to achieve the aims and objectives of the research. Also, it will cover the rationale for the choice of methods and techniques utilised to gather the required data.

Chapter 4: Research Methodology

4.1 Introduction

This chapter discusses the followed methodology in this research, which is a critical element to achieving the research aim and objectives.

Selecting the methodology, which is suitable for this research, is important in choosing specific questions for research; that is because collecting data for the designed framework depends on the type of methodology, strategy and approach of the research. The research questions and associated aims and objectives were designed to explore and define why energy management programs have not implemented in hospitals and health care sector. At the same time, the generated reports and documents focused on the energy consumption in hospitals, considering any changing and increase in demand during the selected period. The interview questions were prepared based on main factors, guided and inspired by the extensive literature review and energy consumption data reports. Also, Interview questions were formulated based on the recent researches and studies' theories and findings.

This chapter covers and discuss the selected methodology in collecting data and the techniques to analyse data to answer research questions which are:

1- What is the actual overall level and characteristics of energy management program in the hospitals?
2- How is energy auditing achieved in hospitals and what are the responsibilities regarding it?
3- What are amount of consumptions and change annually for the energy in the hospitals; what are types of usages and electrical loads and blackout in hospitals and most significant factors effect on energy consumption?

4- What are the barriers to energy efficiency in the hospitals and to what extend they can effect on energy performance in the hospitals?
5- What is the level of awareness of energy management in the hospitals and what are the barriers and drivers to promote it?
6- What are the motivations for energy savings in their organisation and estimating the amount of saved energy?

Saunders recommends that before selection the methods for collecting data, the researcher should carefully consider aspects or layers which represent research onion. These are research philosophy, research approach; research strategy; choices, time horizons and technique and procedure. (Saunders et al., 2007). Figure 4-1 shows research layers as Saunders stated.

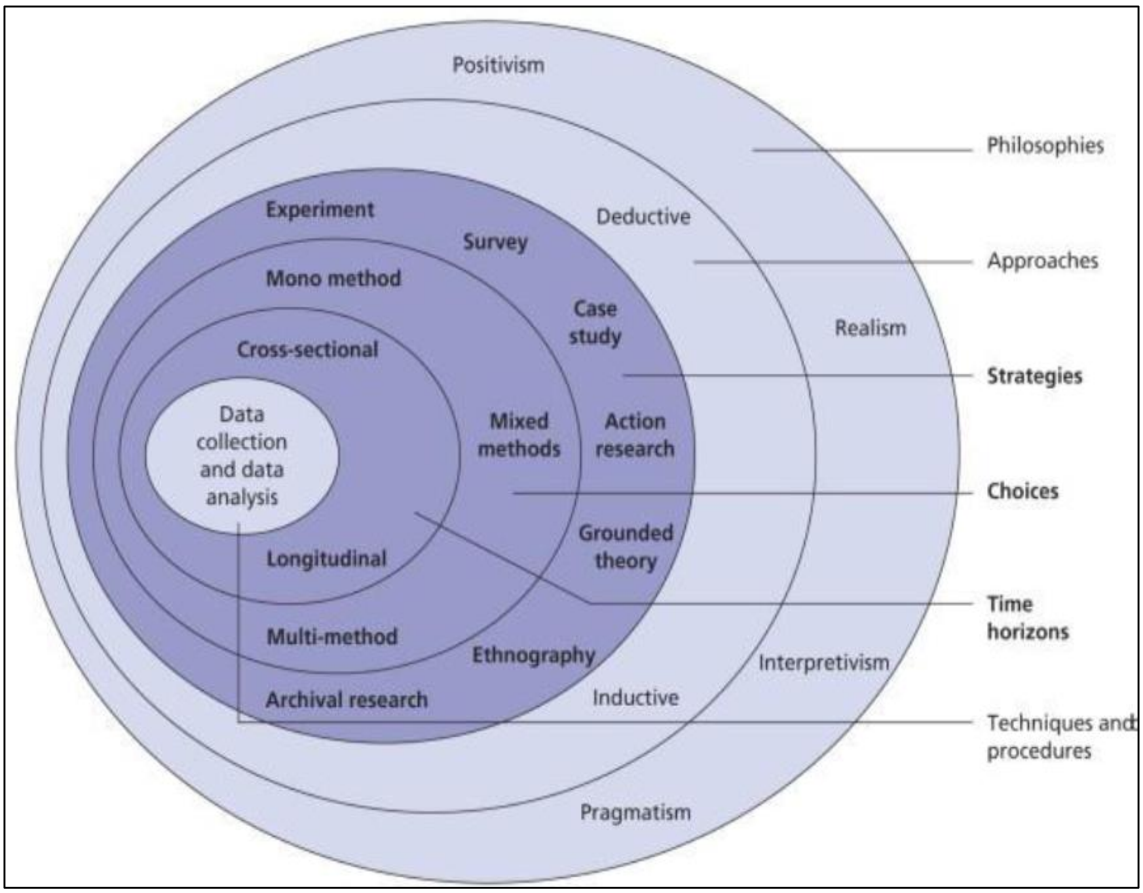

Figure 4-1: Research Layers. (Saunders *et al*., 2007)

Remenyi et al (1998) defined 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". In addition, Collis and Hussy (2009) identified the methodology as "overall approach to the entire process of the research study".

4.2 Research Philosophy

Identifying the philosophy of the research is most important step that will help the researcher to answer research questions about phenomena that wants to study.

There are two philosophies for researches and both are merged in this research and are positivism and interpretivism. The research can integrate these methods of philosophies in the search to explain research problems and that lack of sufficient information as Saunders states (Saunders *et al*., 2007). Moreover, Myers and Klein (1999) stated that

"Positivists believe that reality is stable and can be observed and described from an objective viewpoint i.e. without interfering with the phenomena being studied"

However, interpretivism the philosophy that based on attempting to establish meanings from people experience and actions which result in pattern. These two philosophies have differences as Collis and hussy (2013) summarised them as shown in Table 4-1.

Table 4-1: Differences between positivism and interpretivism , (Collis and Hussy, 2009)

	Positivism	Interpretivism
1	Concerned with hypothesis testing	Concerned with generating theories
2	Associated with quantitative approach	Associated qualitative approach
3	Reality is objective	Reality is subjective
4	Knowledge is based on observable facts outside of the human mind	Knowledge is determined by people rather than by objectives external factors
5	Scientific	Humanist
6	Uses large samples	Uses small samples
7	Data is highly specific and precise	Data is rich
8	Deductive approach	Inductive approach

In this research, positivism philosophy is the first appropriate used philosophy in the context of this research. The reason for that is availability of hypothesises and scientific variables and measurements to categorise types of energy usage in the hospitals and the expected electrical loads and factors that may effect on them. Also, positivism philosophy helps to explore the relationships between set of operationalisation of concepts and variables to test of the validity theory because generalising data is important while that relationships can structured by specific samples involved in collecting data process as Saunders stated.

Interpretivism philosophy attempts to understand situations and issues in the reality by investigating people viewpoint and their behaviour in the circumstances and the perspective which they perform within (Stoop & Berg, 2003). So, Interpretivism philosophy is second appropriate used philosophy in this research due to need to understand how energy audit process is achieved in the hospitals and why energy management is not implemented and what level of awareness of energy management is and how to promote it from energy managers' prospective.

4.3 Research Approach

This section discusses the research approach that adopted in this research. The most of approaches in the researches fall under two main domains. These are qualitative (inductive) and quantitative (deductive) approaches. But, there is third approach which is mixed between these two methods. That method called mixed approach method. In addition, Dewey states that the one research study can use and combine inductive and deductive philosophies by describing it by “double movement of reflective thought”.

There are differences between these approaches. This comparison between two approaches can be summarised in Table 4-2 (Saunders et al., 2007).

Table 4-2: Comparison between two approaches (Saunders et al, 2007)

	Deduction	Induction
1	Scientific principles	Gaining an understanding of the meanings humans attach to events
	Usually begins with a hypothesis	Usually use research question to narrow dawn the scope of the study
2	Moving from theory to data	In-depth knowledge of the topic
3	Liked with quantitative data	Liked with qualitative data
4	Highly structured approach	More flexible structure

Based on what is mentioned above and Table 4-2, these are the reasons for selecting approaches for this research:

One of the research objectives is determining amount of consumptions, change rates annually for the energy in the hospitals usages, amounts of electrical loads and number of blackout in hospitals. Deduction approach focus on scientific principles and linked with quantitative data as mentioned above in table. It helps in focusing more on counting and categorizing features and statistical. That is helpful to answer part of this research questions which related to what type of applications for energy in hospitals, how many blackouts in hospitals, and how much energy consumed every year and what amount of load are. Also, it helps to measure the prevalence and incidence of phenomena because deduction approach is moving from theory (which highlighted in the literature review) to data (part of results in this research).

Induction approach focuses on investigations into deeper details such as attitudes, ideas, thoughts and behaviours. Also, it provides more flexibility in structuring factors and data. Based on that, the qualitative approach is suitable to answer research questions which related to awareness of energy management in the hospitals, the barriers and drivers to promote it depending on the staff experience and understandings.

The mixed approach, quantitative and qualitative research approaches, is commonly the most used in different fields as (Cohen and Manion, 2013) illustrated

4.4 Research Strategy

Saunders et al (2007) defined research strategy as "the general plan of how the researcher will go about answering the research questions". Also, Bryman (2008) described research strategy as "a general orientation to the conduct of research". Moreover, there are variety in research strategies that followed in the researches. It is very important to choose the most advantageous strategy for a specific research study. Experiment, survey, grounded theory, case study, action research, cross sectional studies, ethnography, longitudinal studies, archival research and participative enquiry are common research strategies that used. (Easterby-Smith et al., 2012; Collis and Hussey, 2009; Saunders et al., 2007).

4.4.1 Case Study Strategy

Yin (2003) described the case study as "empirical inquiry that investigates a contemporary phenomenon within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident". Collis and Hussey (2009) defined case study strategy as "a methodology that is used to explore a single phenomenon in a natural setting using a variety of methods to obtain in-depth knowledge". So, case study strategy can accommodate together qualitative and quantitative data which allow the researcher to get rich mix of data for the research as Yin (2003) and Gerring (2006) agreed.

Depending on that, this research is considering case study strategy as the most appropriate research strategy to answer this research questions. This research attempts to use quantitative and qualitative data to make rich mix that allows deep investigation and understanding for energy management programs performance in hospitals. Also, it allows for better understanding about energy efficiency barriers and awareness to energy management in real situations depending on staff experience.

4.5 Research Methods

As mentioned previously in research approach this research is not adopts mono approach. It adopts mixed approach by using quantitative and qualitative methods to help achieving research aim and objectives. Because of that, this research will use mixed methods instead of mono method to collect data. These Methods are:

4.5.1 Quantitative Method

This type of method concerns in converting data into numbers (Deeptee & Roshan, 2008). Quantitative method is most appropriate method to generate numerical data which lead to generalization of results. Because it provides information can be analysed statistically.

4.5.2 Qualitative Method

This method can provide powerful tools for research in subjects such as general management, organisation and more (Gummesson, 2000). Social sciences have developed the qualitative research method in order to help researchers to study social and cultural phenomena (Avison & Pries-Heje, 2005). Also, it attempts to provide deep understanding of people, situations and organisations in their social cultural context (Myers, 1997). So, the qualitative method gathers information depending on meanings, ideas and words not numbers and equations.

There are many techniques which can be used in qualitative research approach such as interviews, case study, focus group, observation and data collection. Interviews are the most common used method or technique for gathering qualitative data (Bryman, 2009). As shown in the literature review, there are many researches in energy efficiency and energy management. However, it may be stated that there is lack of researches in healthcare which discussed energy management in healthcare. So, to understand the current energy management programmes in healthcare, the demand for detailed data becomes and selecting qualitative method is most appropriate to generate ideas and hypotheses to this research.

4.5.3 Comparing Between Quantitative and Qualitative Methods

There are many differences between quantitative and qualitative methods. Table 4-3 shows some of differences between these methods as Bryman and Bell stated (Bryman and Bell, 2011)

Table 4-3: Differences between quantitative and qualitative methods (Bryman and Bell, 2011)

Dimension	Qualitative	Quantitative
Concepts	Research development	Operationalised
Approach	Unstructured, driven and open	Structurally driven
Focus	Connects events, activities, factors and people interpretation	Change in social world by static style
Relation between field and researcher	In-depth investigation by close view of the event	General with no deep investigation of subject
Relation between respondent and researcher	Close and direct contact	Indirect contact
Findings	Deep and rich data	General and specific data with no attention to time or place, inflexible and reliable

The reasons to select mixed method in this research are:

1- One of the research objectives is determining amount of consumptions, change rates annually for the energy in the hospitals usages, amounts of electrical loads and number of blackout in hospitals. Quantitative methods that focus on numbers and frequencies instead of on meaning and experience. They focus more on counting and categorizing features and statistical. They are helpful to answer part of this research questions which related to what, how many, and how much, and can be used to measure the prevalence and incidence of a phenomena.

2- Qualitative approach focuses on investigations into deeper details such as attitudes, ideas, thoughts and behaviours. Also, it provides more flexibility in structuring data. Based on that, the qualitative approach is suitable to answer research questions which related to awareness of energy management in the hospitals, the barriers and drivers to promote it.

4.6 Research Process

This research is achieved in six stages. Figure 4-2 shows the stages of research process. This flowchart helps the researcher to organise research process and progress. The first stage is defining the research problem, aims and objectives of the research and defining research questions.

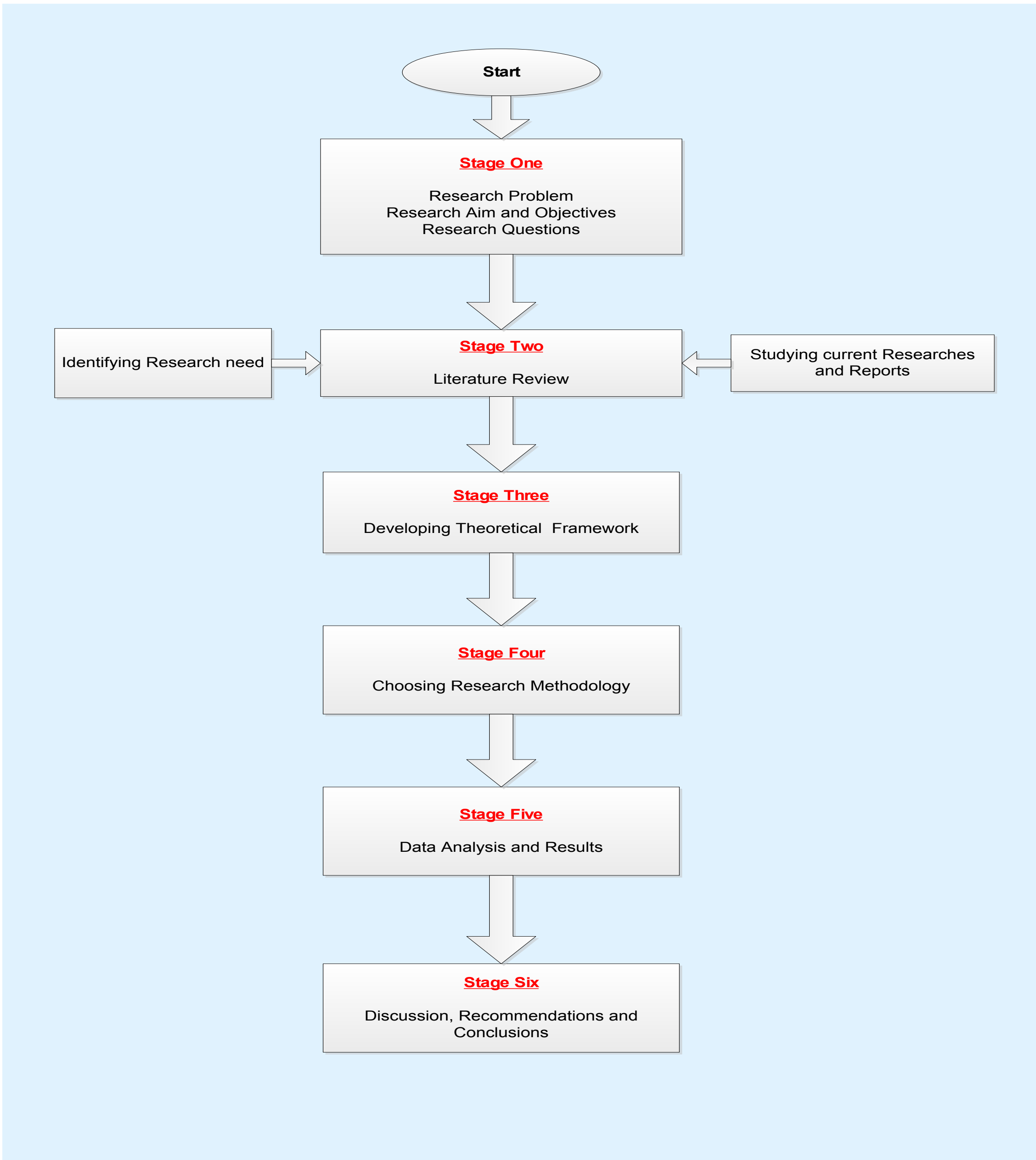

Figure 4-2: The stages of research process.

The Second stage is identifying research needs and studying current researches and reports to help the researcher to develop the theoretical framework that used in this research.

Before developing framework that used in this research, which is the third stage, it is important to consider that energy management program should include four main sections to be effective. These sections are:

1. Analysis of historical data;
2. Energy accounting and auditing.
3. Technical analysis and investments plans based on feasibility studies;
4. Personnel information and training. (Petrecca, 2012) and (Kannan, 2003)

For strategic energy management practices, John describes similar recommendation: set goals for efficiency, capture data and communicate on-going energy performance to stakeholders in the organization (John, 2004).

To achieve aims of this research and depending on that and the recent researches and their findings that covered in the literature review in Chapter 2 and Chapter 3, the theoretical framework is developed to address the key shortcomings of existing energy management programs and also to help the researcher to provide practical guidance to implement an energy management in hospitals in Saudi Arabia. As shown, Figure 4-3 the theoretical framework which developed by researcher based on recent researches and their findings that covered in the literature review.

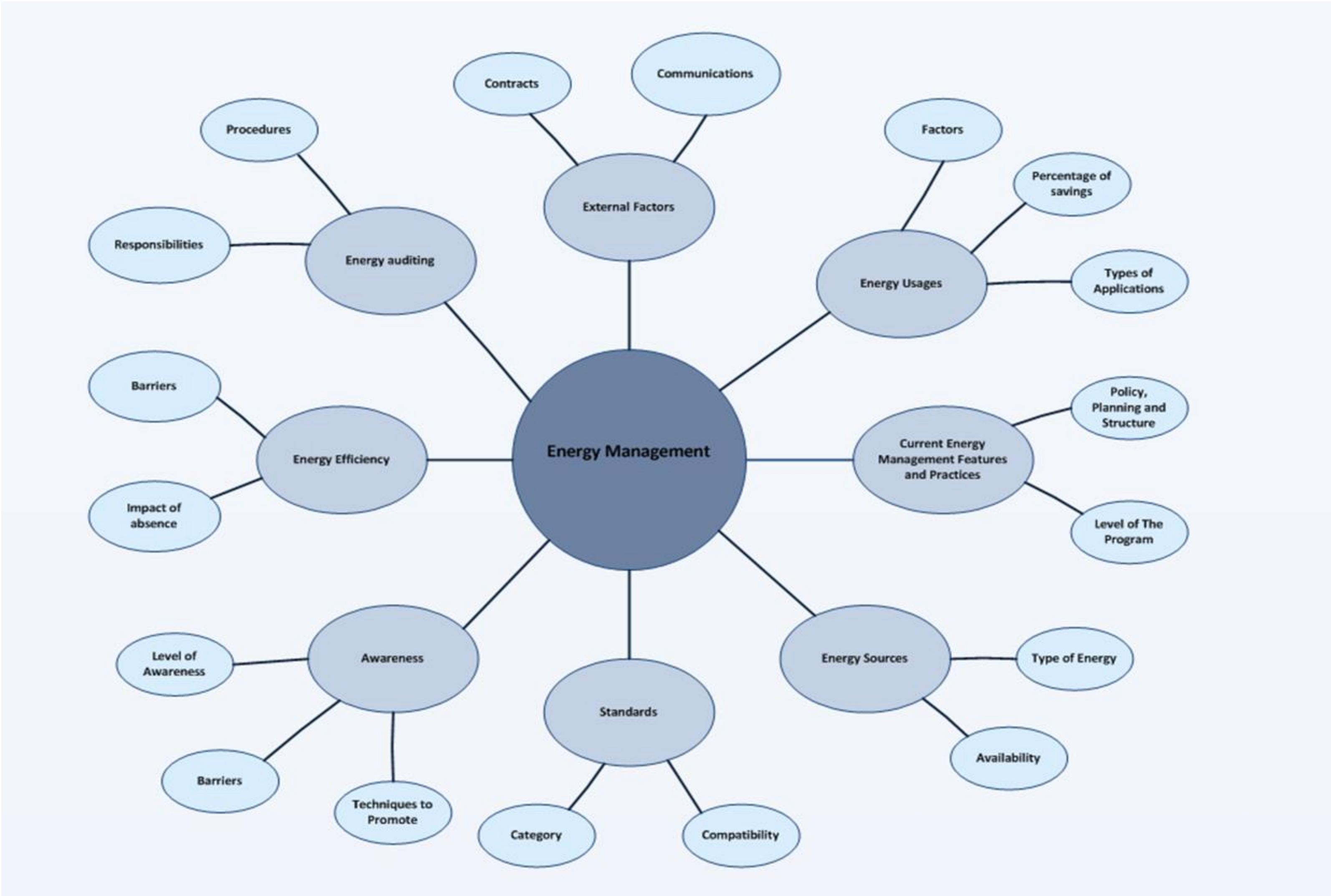

Figure 4-3: The theoretical framework which developed by researcher.

This chapter discusses research methodology and research strategy that used in the research. This stage represents the fourth stage. This stage also includes the methods and procedures that followed to collect data.

4.6.1 Data Collection

There is lack of data about energy management in Saudi Arabia. For this reason, two separate but inter-related studies, aiming to better characterize energy consumption and to investigate in energy management in this country, were conducted. Study A, which involved the assessment of the level of energy management program and the gathering of energy consumption quantitative data from five hospitals, and study B, which involved the inspection of the opinions of hospital top technical managers regarding energy management in their hospitals. The aims of study A were determining the level of implementation of energy management program and the amounts and percentage of annual change in electricity consumption per bed in hospitals.

Then, study B involved gathering the opinions of Technical managers, with the objective of becoming acquainted with their knowledge in auditing procedures, awareness to energy management, percentage of expected amount of saved energy if we applied energy management, barriers of energy efficiency, and so forth. More specifically, the aims were:

- Determining and understanding the level and characteristics of energy management programs in hospitals.
- Energy auditing procedures and how to produce information regarding it.
- Exploring the barriers energy efficiency and their affects in hospitals.
- Assessing the awareness about energy management in the hospitals and what factors that effect on it.
- Exploring the opportunities for energy savings in hospitals and estimating the amount of saved energy.

In this research, multiple data collection methods are used to conducts studies A and B. Yin (2003) states that there are such sources of evidence that used in case study strategy such as:

- Documentation.
- Archival records.
- Interviews.

Table 4-4: The strength and weakness of these sources.

Source of evidence	*Strength (Yin, 2003)*	*Weakness (Yin, 2003)*	*Way of employment of resource in this research*
Documentation	- Stable - exact - Broad coverage	- Can be low - Biased. - may be blocked to for access.	Hospital details such as: categories, capacities and facilities
Archival Records	- Stable - exact - Broad coverage - quantitative - Precise.	- Can be low - Biased. - may be blocked to for access. - Privacy reasons may effect on accessibility.	Details such: - Energy consumption bills and costs from energy supplier. -Electrical loads. -Blackouts.
Interviews	-Insightful. - focus directly on case study topic.	- Biased in the response. -Inaccuracies.	Semi-Structured Interviews with top managers in the sector.

4.7.1.1 Quantitative Data

For study A, the hospitals were chosen based on the Ministry of Health classification for hospitals and its own system. These hospitals were general referral or specialized referral hospitals which represented the major category or type of hospitals in the Ministry of Health. Energy matrix is used to determine the level of implemented energy management program in the hospitals. Then, reports of energy consumption in the last two years were requested to the energy supplier (Electricity Company). These were then used to study energy consumption in those hospitals. Only five reports were made available. These were consulted by the researcher and data concerning the last two years was registered on a separate file for subsequent analysis.

Also, the researcher gathered details from the hospitals records these details:

1. Major electrical loads (Air conditioning, Boilers, water desalination stations and medical devices).
2. Number of blackouts per year.
3. Number of successful responses to blackouts.
4. Number of backup generators and UPS.
5. Capacity of hospitals.

4.7.1.2 Interviews

In the interview, interviewer can determine the interviewee and the style of interview depending on the purpose and type of required information for the research. Research interviews also aim to gain information and understand issues may relate to main targets and specific questions (Gillham, 2000). When the researcher is collecting data and investigating to more information, interview is optimal method especially when the discussed topics become sensitive (Gill, P. et al, 2008). So, interview is the appropriate technique to collect data due to lack of resources and researches in energy management in healthcare sector. In general, the types of interviews are structured, semi-structured and unstructured interview (Oates, 2005). The semi-structured interview is developed in this research to allow for more focus and elaborating in the conversation because semi-structured interview is featured as flexibility method and enable for focused, conversational and two-way communication (Mukherjee, 2004)

Study B’s face-to-face, purpose-built; semi- structured and written transcript interviews were conducted. Yin (2003) stated that “interviews of this nature tend to reach a point of data saturation after interviews with about eight individuals”. So, 18 people of top technical managers were interviewed. The literature review informed item generation and questions. These questions are detailed in the following section. The interviews were then transcribed and analyzed.

The interview consisted of 21 questions. The survey consisted of 21 questions. It started by inquiring interviewees about their function and experience at the hospital, and then focused on their opinions about energy management. Namely, it asked about the meaning of energy (Q3) and energy management (Q4) and about the types of energy used in the hospital (Q5).

It then focused on energy management plans and practices, by inquiring about their energy management plans (Q2), the benefits of energy management plans (Q6), energy savings possibilities (Q7), energy efficiency barriers (Q8) and risks (Q9), the hospitals' current energy efficiency plans (Q10), the department (s) and inter-departmental communication about energy expenses and their payments (Q11), the current energy consumption review (Q12), consumption-activity analysis (Q13), forecasts (Q14), their thoughts about current energy wastes (Q15), personal estimations and used indicators (Q16), the honouring of existing energy agreements (Q17), the use of technical advice (Q18), and the extent and reasons for hospitals management commitment towards following their capacities (Q19), and about the staff awareness (Q20) and awareness promoting plans (Q21) about energy savings' possibilities. That is, the last section focused both upon the hospitals' current energy management practices and struggles and existing energy management plans. The list of questions can be observed in Appendix B.

4.6.2 Data Analysis

Data analysis stage represents the fifth stage in this research. To complete analysis process the suitable software was used for quantitative data analysis and for graph drawing. The hospitals provided monthly energy consumption data, allowing for the determination of annual totals. These values were used to calculate energy consumption per hospital's capacity. The equation adopted for calculating energy consumption was:

Energy Consumption of Hospital per Bed = Energy consumption (kWh) / number of beds (1)

For the survey's open questions, a simplified version of the qualitative content analysis (QCA; Mayring, 2000) method was chosen. QCA is a relatively concrete and descriptive approach to qualitative data analysis. It uses a rule-based, trustworthiness-enhancing method to categorise data, via theory-driven (theoretical meanings of empathy) and data-driven (empirical meanings of empathy) processes. Thus, it is neither purely inductive nor purely deductive. It uses both of these processes iteratively; and it allows for a methodological mixed approach (Creswell, 2013) to data. The answers generally had a straightforward interpretation and there was a minor necessity of recurring to implicit meanings. Thus, this seemed like an adequate choice.

The analysis started with the establishment of a category-formation criterion. The analysis was done question per question, thus the criterion adopted was defined by the question itself. For example, the Q5 inquired about the types of energy used in the hospital, and, thus, the criterion was 'types of energy'. Via an iterative reading and re-reading process, a set of categories (short descriptive labels illustrative of recurrent meanings) was established and refined. Since there were not many participants and usually not such a great amount of categories, every developed category is reported upon. Sometimes, the analysis process yielded that the use of a hierarchical structure to the set of categories would facilitate the exposition and understanding of results. Therefore, a hierarchical structure was sometimes used to illustrate a question's results.

This analysis was conducted, were the questions, answers, and associated categories were listed. QCA further offers the possibility of assessing the frequencies of each category.

4.6.3 Credibility and Reliability

For anonymization purpose, the hospitals were named H1, H2, H3, H4 and H5. When necessary, pseudonyms were used for interviewees and their accounts were fully anonymized. This increases the study's credibility. Moreover, the hospitals' capacity was taken into account for determining energy use per hospital, thus improving the validity of the energy-related quantitative results. This allows for auditing procedures, thereby increasing the study's credibility. The research is also enhanced by triangulating by data source. Triangulation can be in these types: data, investigator, theory and methodological as Yin (2003) reported. In the present case, energy suppliers and hospital technical managers provided data for separate inter-related studies (A and B), and different hospitals and managers from the same sector were consulted. This triangulation procedure is often argued to increase the quality of the data and the trustworthiness of the analysis. Similarly, and with the same advantages, there was triangulation by method (interviews and energy consumption information), by theory (using different theories, for example, for item-generation), and by data type (combining quantitative and qualitative data).

4.7 Summary

This chapter covered the research method developed initial stages of the research and used to gather information to achieve the aim of the study. Also, it covered the main research objectives targeted by these techniques. The next chapters cover the sixth stage of the research, which is the analysis of the results in order to propose the discussion and recommendations of the study.

Chapter 5: Findings and Results

5.1 Introduction

The present research discusses energy management's definition, benefits, barriers, and standards in Chapter 2. In Chapter 3, it focuses on energy consumption reports in hospitals, breaks down their consumptions, and determines factors that influence energy consumption and the type of energy consumed in the targeted countries. The applied methods of the research are justified and criticised in previous chapter in this thesis.

In this chapter, the research provides deep analysis for the data, which was gathered using different techniques to increase the validity and reliability of this research. This chapter is divided into two main parts.

The first is the researcher's analysis of the data gathered from targeted hospitals. It includes: 1) major electrical loads, including air conditioning, boilers, water desalinisation stations, and medical devices; 2) the number of blackouts per year; 3) the number of successful responses to the blackouts; 4) the number of backup generators in each hospital; 5) the capacities of the hospitals; and 6) the hospitals' energy consumptions and costs per year. The second part of the chapter analyses the data gathered from the interviews conducted with stakeholders in MOH in Saudi Arabia.

Before the analysis, the research should provide some background about the Ministry of Health in Saudi Arabia to provide a deeper understanding of the targeted organisation.

5.2 Background on MOH in Saudi Arabia

Ministry of Health, in Saudi Arabia, is a governmental sector which managed and operated mainly by the government. It provides free health services for all Saudi citizens and certain non-Saudi citizens who work in governmental sectors.

MOH has 270 Hospitals. Number of beds in MOH hospitals represents 59% in Saudi Arabia, shown in Table 5-1, Figure 5-1 and Figure 5-2.

Table 5-1: Hospitals in Saudi Arabia by sector type.

Sectors	Hospitals	Beds
Ministry of Health	270	40,300
Other Governmental Hospitals	42	12,032
Private Hospitals	141	15,665

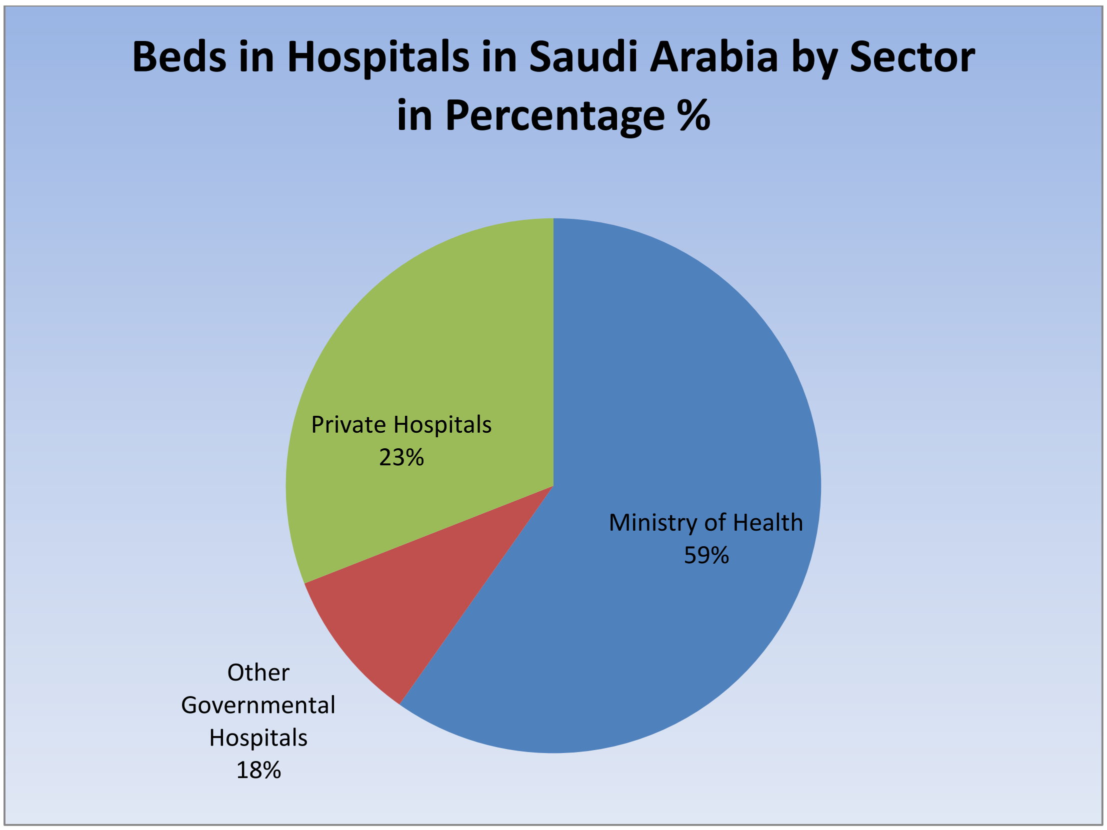

Figure 5-1: Number of beds in hospitals in Saudi Arabia by sector type in percentage (MOH-Health Statistical year Book, 2014).

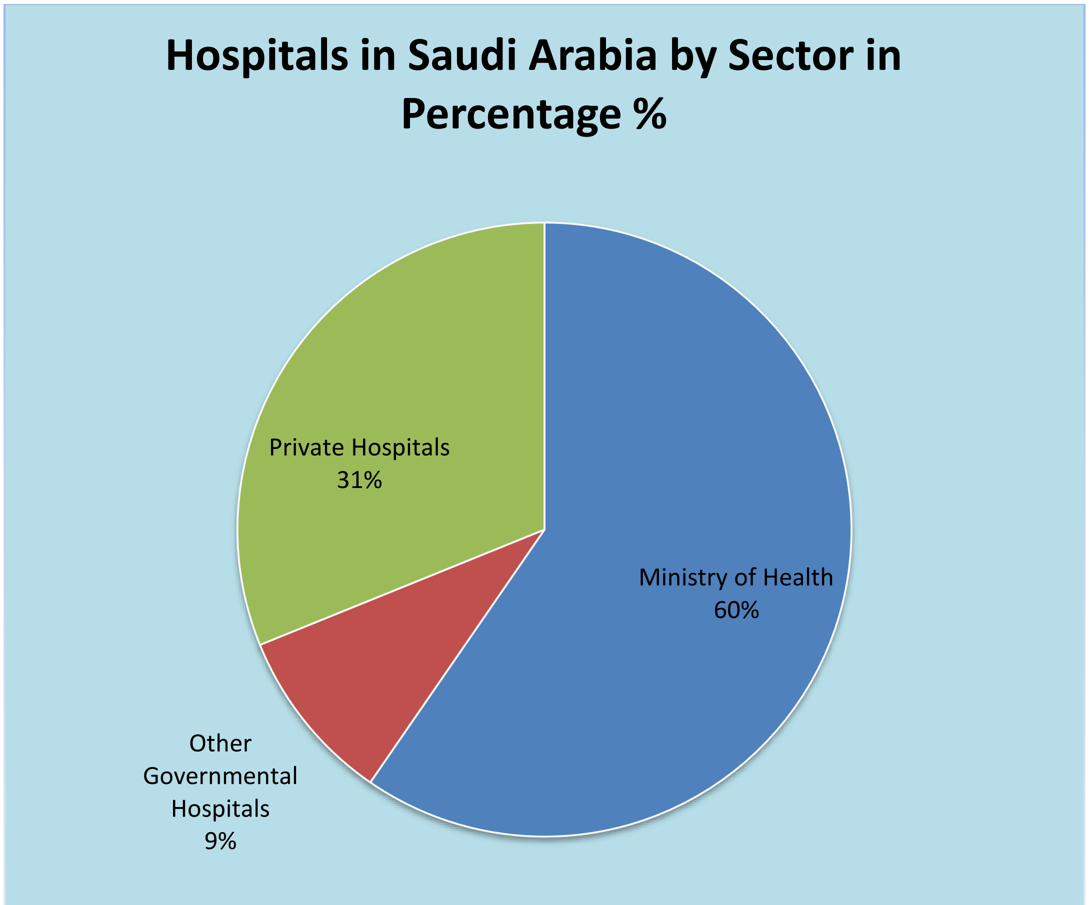

Figure 5-2: Hospitals in Saudi Arabia by sector type in percentage %.(MOH-Health Statistical year Book, 2014).

A financial appropriation from the government budget for MOH is corner stone of health resources in Saudi Arabia. Also, it rises every year. For example, for year 2014 the percentage of financial appropriation for MOH represents 7.01% of total government budget with increase rate by 0.41% in year 2013 (MOH-Health Statistical year Book, 2014).

5.3 Quantitative Results

This section shows the results for the quantitative results in the first study in this research. It covers energy matrix score for the hospitals, energy consumptions then electric loads, generators and UPS details.

5.3.1 Energy Matrix

Energy matrix was applied to the hospitals to assess level of the energy management practices in the hospitals. It is found that the level of energy management practices were very low. It can be considered that no energy management practices in the hospitals as Table 5-2 shows that.

Table 5-2: Energy Matrix in Hospitals in Saudi Arabia.

LEVEL	ENERGY POLICY	ORGANIZATION	MOTIVATION	INFORMATION SYSTEMS	PROMOTION	INVESTMENT
4						
3						
2						
1			X	X		
0	X	X			X	X

5.3.2 Monthly Energy Consumption in kWh

Five hospitals, here named H1 to H5, provided quantitative data regarding their energy consumption monthly practices concerning the last two years, here named year 1 and 2. The monthly consumption of H1 had, for the first year, a total of 7,326,543 kWh and an average of 610,545 kWh (SD=154,727.1 kWh). The monthly consumption registry is illustrated by Figure 5-3. Figure 5-3 suggests that there are months across the two years which involve more energy expenditure. Specifically, energy consumption seems to peak around first months of the year for this hospital, and in comparison with the last months of the year.

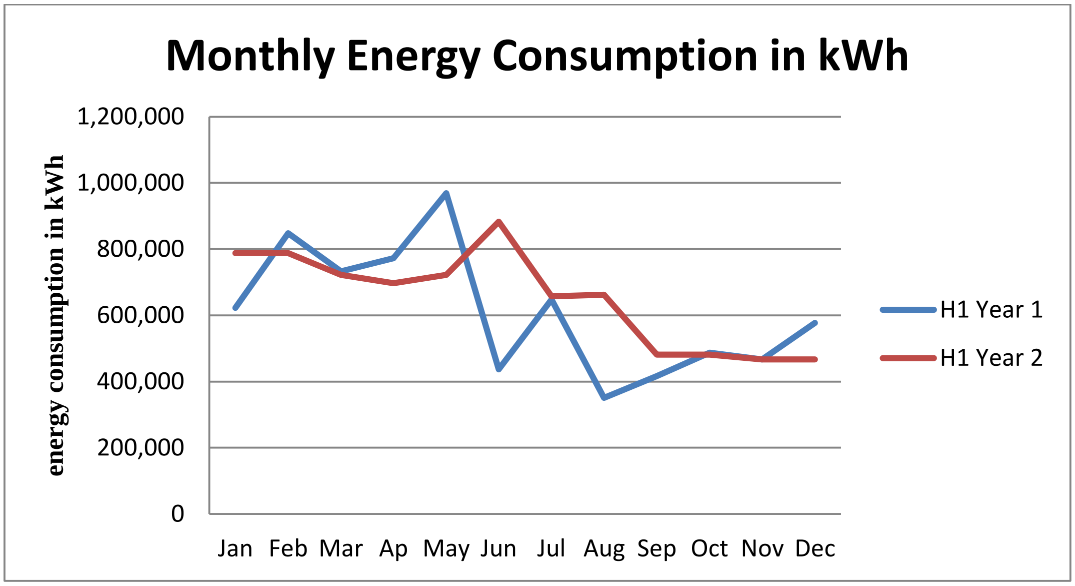

Figure 5-3: H1's monthly energy consumption in kWh.

The monthly consumption of H2 had, for the first year, a total of 937,000 kWh and an average of 78,083 kWh (SD=22,402.8 kWh). The monthly consumption registry is illustrated by Figure 5-4. The same variation pattern, with higher consumption for the first months of the year, can also be observed.

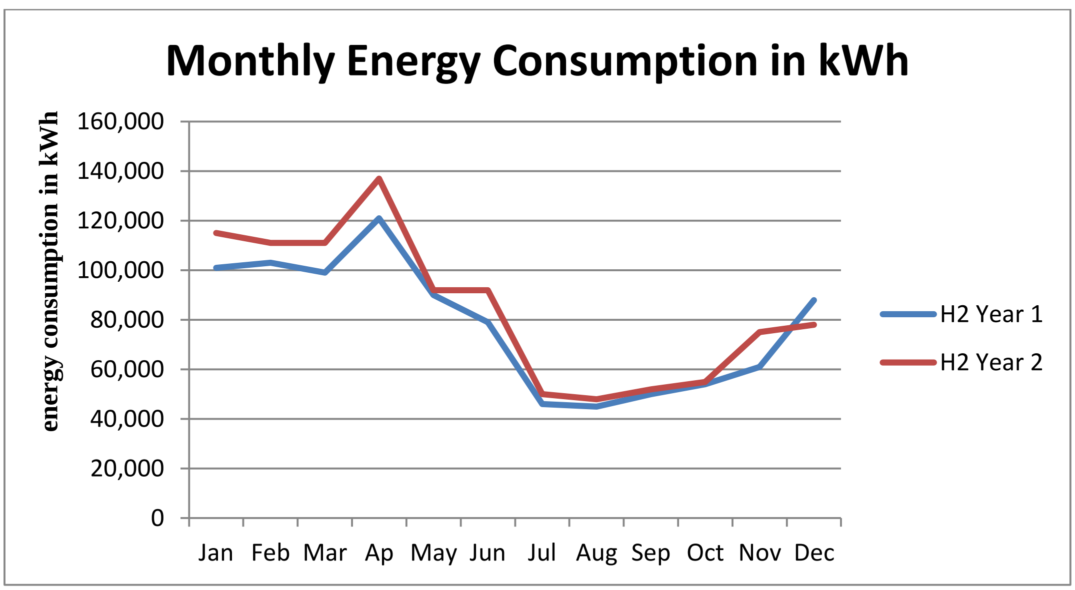

Figure 5-4: H2's monthly energy consumption in kWh.

The monthly consumption of H3 had, for the first year, a total of 6,148,000 kW and an average of 512,333 kWh (SD=211,777.8 kWh). The monthly consumption registry is illustrated by Figure 5-5.

It is possible to observe that there are two months (February in Year 1 and December in Year 2) were the registered consumption is 0. Such absence is very important to notice because results. It will be discussed in the conclusions section of this report. . If affects total consumptions and average consumptions for this hospital in particular, decreasing values. That is, the results here obtained are lower than actual expenditure values. This absence further affects the totals, means and standard-deviations obtained for each year and across, and across years and hospitals – values which will be discussed in the following section.

Nevertheless, the expenditure pattern observed for H1 and H2 seems to be repeated here too, with a peak in the beginning of the year.

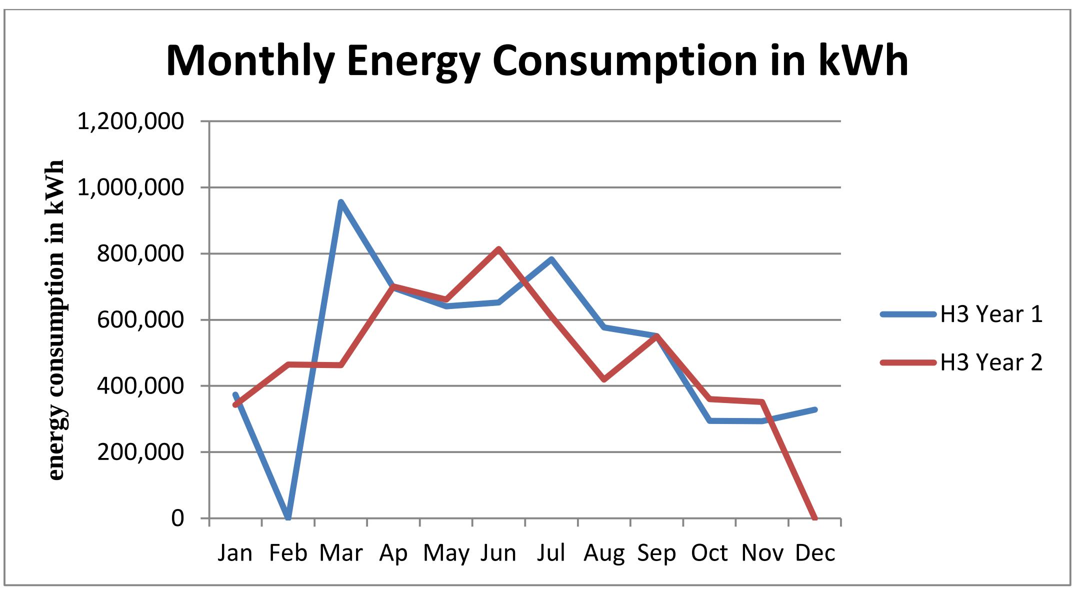

Figure 5-5: H3's monthly energy consumption in kWh.

The monthly consumption of H4 had, for the first year, a total of 4,511,000 kWh and an average of 375,917 kWh (SD=141,888.9 kWh). The monthly consumption registry is illustrated by Figure 5-6. This Figure shows how, as with H3, there were three months in Year 2, specifically, September to November, during which consumption equaled zero. This very important observation is discussed in the conclusions section.

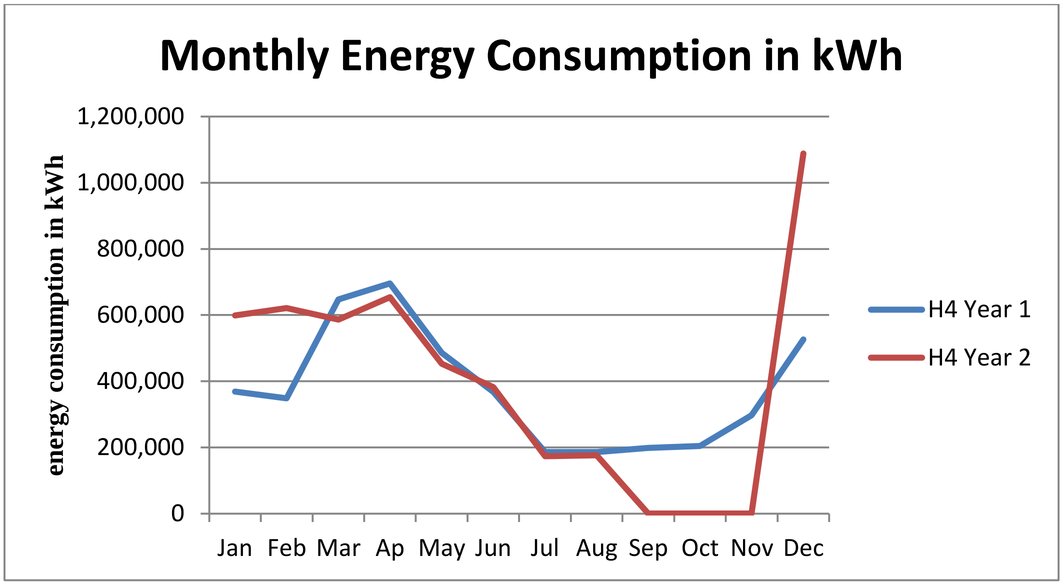

Figure 5-6: H4's monthly energy consumption in kWh.

The monthly consumption of H5 had, for the first year, a total of 16,570,000 kWh and an average of 1,380,833 kWh (SD=354,027.8 kWh). The monthly consumption registry is illustrated by Figure 5-7. As with the other hospitals, the peak consumption occurs during the first months of the year and decreases in the second half of the year.

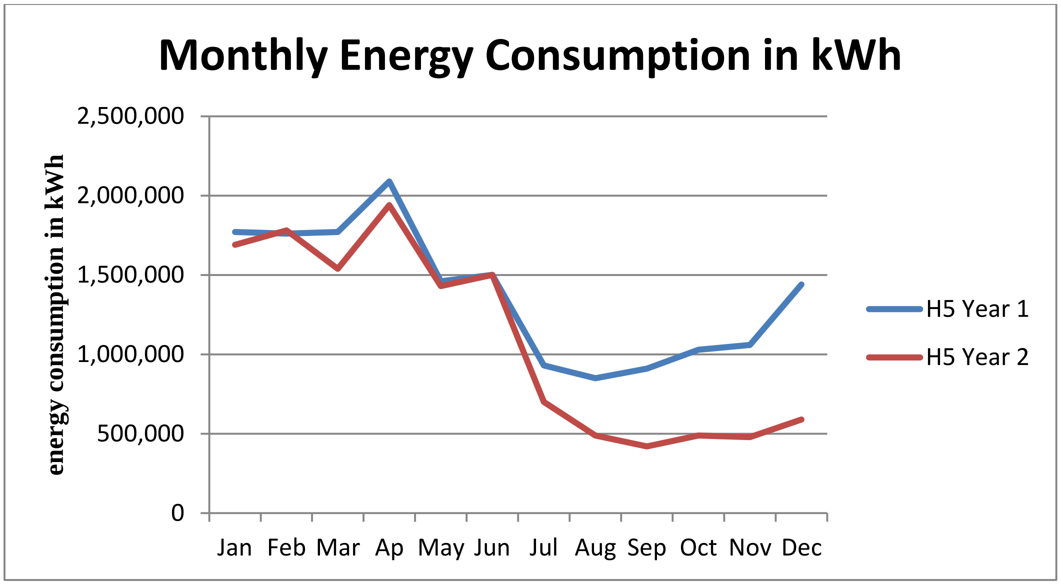

Figure 5-7: H5's monthly energy consumption in kWh

5.3.3 Annual Energy consumption in kWh

The disclosed information allowed for the determination of annual consumptions per hospital. The total consumption per hospital is illustrated by Figure 5-8. Overall, the total consumption for year 1 was 7,326,543 kWh and 7,818,325 kWh for year 2; and, across the two years, 15,144,868 kWh. This shows a slight increase in energy consumption from year 1 to year 2. A more detailed observation of each hospital's annual consumptions shows how H3 and H5 consumed more energy for year 1. That is, it does not follow the general increasing trend. H3 did not report energy consumption for two months of the first year. That is, the absence of data did not refer to the second year, and therefore such counter-trend cannot be explained through this aspect.

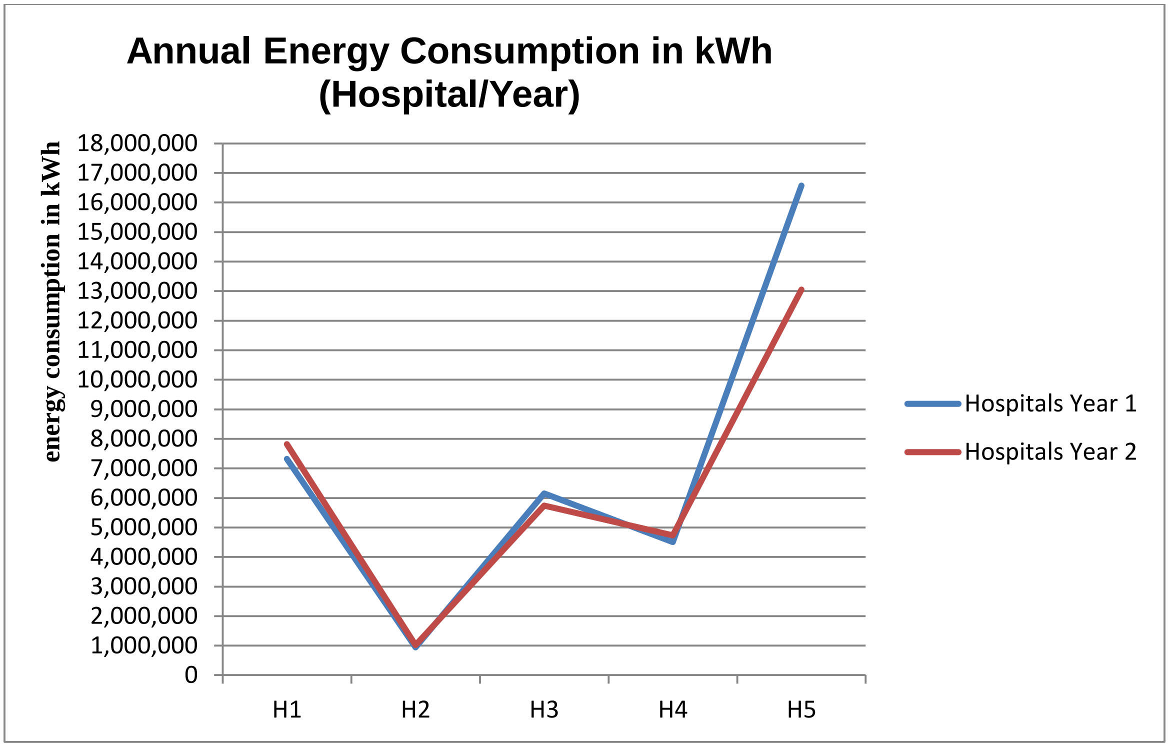

Figure 5-8: Annual energy consumption in kWh per hospital and per year

Each hospital's annual energy consumption, in kWh, per bed and per year is illustrated in Figure 5-9. Please note that the number of beds was identified once. It is unknown whether the number of beds varied across the years. This can be regarded as a limitation of these results.

As it can be observed, the H2 had the lowest energy consumption, namely 937,000 kWh for year 1 and 1,016,000 kWh for year 2. H1 managed to decrease energy consumption for year two and it has an almost as low consumption rate than H2, namely 1,063,854 kWh. The H5 was the hospital consuming the greatest amount of energy, more specifically 16,570,000 kWh for year 1 and 13,050,000 kWh for year 2.

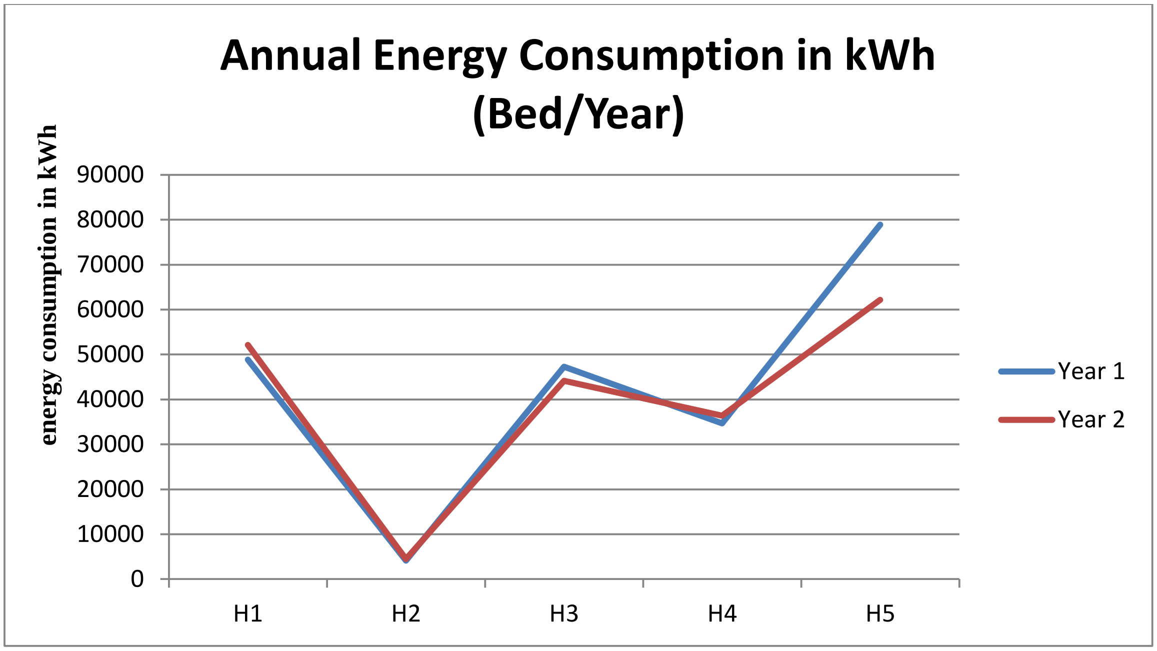

Figure 5-9: Annual energy consumption in kWh per bed and per year

5.3.4 Electric Loads, Blackouts and Generators

The total electric loads were very diverse. The average was 3,534 Amp (SD= 2,252.8 Amp). Such great variation happened within a wide interval, namely, 1600 Amp to 7400 Amp.

There were two hospitals with three blackouts, two with four blackouts and only one with 18 blackouts, each of which successfully responded to. The hospital experiencing greater number of blackouts can be considered an outlier. In this case, was with the case of electric loads, it is not very meaningful to discuss means and averages. For example, the blackout's mean was 3.5 (SD=O.5) without the 'outlier', and 6.4 (SD=4.64) without the outlier.

As for generators and UPS, one hospital had one, one hospitals had two, and three hospitals had three, giving a mean of 2.4 (SD=0.7). Yet, in one case it was noted that the generator(s) needed replacement. Tables 5-3, 5-4, 5-5, 5-6 and 5-7 show details for H1, H2, H3, H4 and H5 respectively.

Table 5-3: Hospital H1 details.

Hospital H1	
Category	Referral Hospital
Capacity	150 Beds
Total Electric Loads	1,700 Amp
Air conditioning	700 Amp
Boilers	25 Amp
Water treatment (declination)	18 Amp
Sewage treatment	27 Amp
Biomedical Equipment	890 Amp
Other	40 Amp
Number of blackouts	3
Successful Responses	3
Number of Backup generators and UPS	2

Table 5-4: Hospital H2 details

Hospital H2	
Category	Referral Hospital
Capacity	225 Beds
Total Electric Loads	5,300 Amp
Air conditioning	3,000 Amp
Boilers	80 Amp
Water treatment (declination)	20 Amp
Sewage treatment	45 Amp
Biomedical Equipment	2,065 Amp
Other	90 Amp
Number of blackouts	4
Successful Responses	4
Number of Backup generators and UPS	3 (doesn't work and need for replacement)

Table 5-5: Hospital H3 details.

Hospital H3	
Category	Referral Hospital
Capacity	130 Beds
Total Electric Loads	1,670 Amp
Air conditioning	570 Amp
Boilers	25 Amp
Water treatment (declination)	18 Amp
Sewage treatment	45 Amp
Biomedical Equipment	840 Amp
Other	172 Amp
Number of blackouts	18
Successful Responses	18
Number of Backup generators and UPS	1

Table 5-6: Hospital H4 details.

Hospital H4	
Category	Specialized Hospital
Capacity	130 Beds
Total Electric Loads	1,600 Amp
Air conditioning	1,000 Amp
Boilers	162 Amp
Water treatment (declination)	45 Amp
Sewage treatment	46 Amp
Biomedical Equipment	247 Amp
Other	100 Amp
Number of blackouts	3
Successful Responses	3
Number of Backup generators and UPS	3

Table 5-7: Hospital H5 details.

Hospital H5	
Category	Referral Hospital
Capacity	210 Beds
Total Electric Loads	7,400 Amp
Air conditioning	3,200 amp
Boilers	50 Amp
Water treatment (declination)	N/A
Sewage treatment	95 Amp
Biomedical Equipment	2,100 Amp
Other	1,400 Amp
Number of blackouts	4
Successful Responses	4
Number of Backup generators and UPS	3

5.4 Qualitative Content analysis' Results

This section discusses the results of the qualitative analysis, which is the second study in this research.

5.4.1 Interview Results

For study B, the participants were five Saudi Arabian hospitals, with an average of 169 beds (SD= 38.8 beds). For study B, there were 18 top management interviewees. The majority (61%) was constituted by managers, sometimes with referred supervisor or assistant functions. There were also directors, location managers and consultors. This is detailed in Figure 5-10. As disclosed, they had an average of 11.67 years of experience, with a standard-deviation of 3.15 years. The minimum was 3 years and the maximum was 19 years. That this, they generally were very experienced managers.

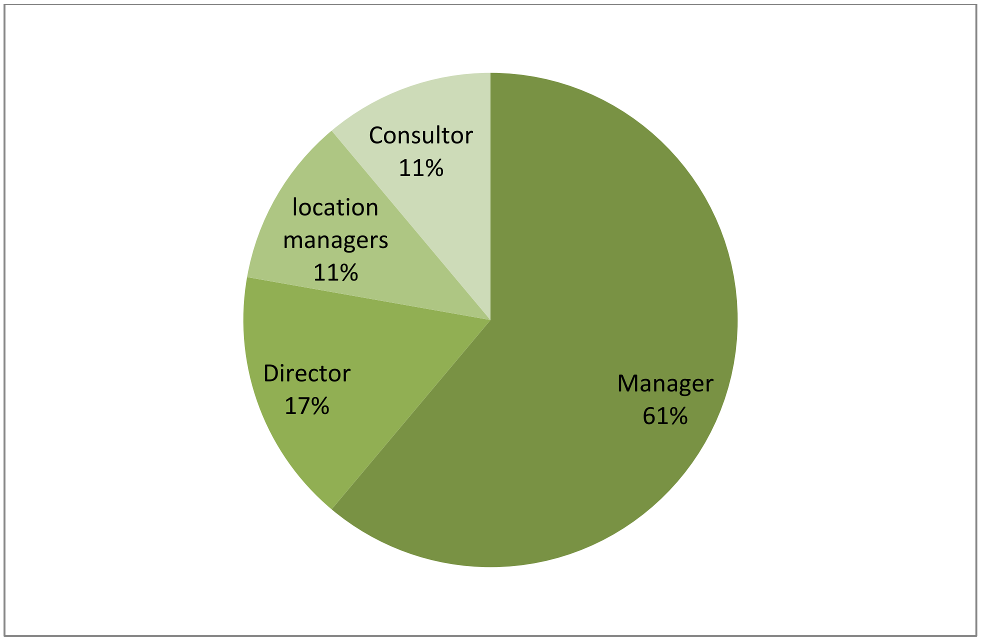

Figure 5-10: Interviewees' function

Q3: Meaning of energy

Participants provided 17 definitions of energy, 14 of which about how energy was a "*work*", "*motion*", or operations and "*functions*" *maker or source*. Two participants referred it was a "*resource*" and eight that it was a "*power source*" or "*source*". Whereas seven saw energy as a "*natural*" or "*physical*" substance, two viewed it as a *produced substance* (that is, requiring transformation to allow use). There were two participants providing examples of forms of energy. Finally, one participant simply remarked energy was an "*important and essential thing to live*". These findings are illustrated by Figure 5-11.

Meaning of Energy

- Resource (N=2)
- Natural or physical substance (N=7)
- Produced substance (N=2)
- Forms of energy (N=2)
- Work or operations or motion maker or source (N=14)
- Power source or source (N=8)
- Important for living (N=1)

Figure 5-11: Meaning of energy categories (and count)

Q4: Meaning of energy management

Every participant described their understanding of energy management. Ten participants defined it as "*controlling*" and/or "*monitoring*" or "*managing*" energy consumption. Fourteen participants mentioned it involved *minimizing consumption* and/*or energy* "*saving*" (e.g., "*with minimal consumption*"), five that it involved *reducing* "*costs*", and two that it involved *finding* "*alternative*" *resources*, and one that it involved *benefiting from savings*, namely those accomplished by minimizing consumption.

Three participants referred energy management had an *efficiency character* and two a *sustainability* character. Finally, one participant simply described energy management as "*the best use of the available resources*" without specifying the character of or the factors involved in such process. These findings can be observed in Figure 5-12.

Meaning of Energy Management

- Controlling and/or monitoring or managing (N=10)
- Minimizing consumption and/or energy saving (N=14)
- Reducing costs (N=5)
- Sustainability (N=2)
- Efficiency (N=3)
- Finding alternative resources (N=2)
- Best use (N=1)
- Benefiting from savings (N=1)

Figure 5-12: Meaning of energy management categories (and count)

Q5: Hospitals' energy sources

Every participant mentioned the use of electricity, sixteen of whom describing it as the main source of energy. Fuel, gas and water were mentioned by seventeen participants. Finally, two participants acknowledged the use of backup generators and two the lack of renewable energy sources. These results are portrayed by Figure 5-13.

Hospital's energy sources

- Electricity (N=18)
- Electricity as main (N=16)
- Gas (N=17)
- Water (N=17)
- Fuel (N=17)
- Backup generators (N=2)
- No renewable energies (N=2)

Figure 5-13: Hospital's energy sources categories (and count)

Q2: Personal energy management plans

At the beginning of the survey, participants were asked about their energy management plans. There two answers that were exactly worded in some way, suggesting a possible data transposition mistake. Alternatively, it would be just a coincidence. Yet, their answers could be clearly divided into two groups and such mistake possibility would not change the conclusions drawn from this question.

Firstly, there were those declaring an *absence of plans* (N=11; 61.1%). Most of these participants expanded upon their answers, providing what seemed to consist of reasons or justifications for such absence. These reasons included the absence of a responsible "*department*" and/or "*personnel*" (*Lacking responsible staff*, N=4), of proper "*legislation*" and/or "*regulation*" (*Lacking proper legislation or regulation* , N=3), of information and knowledge, such as about "*energy savings*" and "*energy consumption*" (*Lacking information or knowledge*, N=4), of "*motivation*" and "*rewards*" (*Lacking motivation*, N=1), and of social, organizational and staff's "*awareness*" (*Lacking awareness*, N=5). Possible additional reasons included not having to pay the energy bills for it being a "*public*" hospital (*Others' expenses*, N=1), the "*low priority*" of energy management (N=6), the changing and research sometimes "*exorbitant*" costs (*Changing and research costs and difficulties*, N=6), and the envisaged *non-significant* "*energy savings*" drawn from such management and change (N=2).

From the ten participants mentioning what seem to amount to motives for the lack of plans, nine remarked they had no personal plans for energy management and did not describe any ongoing or prospective hospital's plan. This was an additional reason for considering these categories as reasons for the absence of plans.

Nevertheless, though not the majority, some participants remarked there currently were "*informal*" or "*not official*" "*plans*" or "*initiatives*" on which some participants personally and actively participated (*Informal plans or initiatives*, N=6) and/or that there were "*prospective*" research plans (N=2). One possible reason for these plans were related to the acknowledged existing energy deficits, "*failures*", or challenges, such as "*high consumption*" and "*main transformer failure*" (N=3). The mentioned plans did not differ, suggesting that their description was possibly put forward by managers from the same hospital. These were: *ongoing "redistribution" studies* or discussions, namely, of energy loads (N=2); and "*new devices*", "*systems*" *and* "*high voltage consumption*" *plans* (N=2). The ongoing or future studies had, as described, a *reducing consumption aim* (N=4). The overall results are illustrated in Figure 5-14.

Personal Energy Management plans

- Absence of plans (N=11)
- Reasons for plans' absence (N=10)
  - Lacking responsible staff (N=4)
  - Lacking proper legislation or regulation (N=3)
  - Lacking information or knowledge (N=4)
  - Lacking motivation (N=1)
  - Lacking awareness (N=5)
  - Others' expenses (N=1)
  - "Low priority" (N=6)
  - Changing and research costs and difficulties (N=6)
  - Changing non-significant savings (N=2)
- Informal plans (N=6)
- Future research plans (N=2)
- Existing energy deficits, failures, and malfunctioning (N=3)
- Ongoing redistribution studies (N=2)
- New devices, systems and high voltage consumption plans (N=2)
- Consumption reduction aim (N=4)

Figure 5-14: Personal energy management plans categories (and count)

Q6: Energy management benefits

Seventeen participants described what they regarded as benefits of implementing energy management systems. Following on what they had already remarked on Q4, they emphasized how energy management had the benefit of *minimizing consumption* (N=7).

The majority also expanded upon the envisaged or expected *economic savings* (N=14; 77.8%), brought not only through the reduction of energy consumption and "*wastes*", but also through a reduction of, for example, "*maintenance*", "*repair*" and staff costs. Another repeated topic was efficiency, more specifically, the *performance efficiency (*N=8). This category included aspects such as "*automatization*", "*failures*" and "*technical*" problems prevention or reduction, and devices "*life span*" increase.

Interestingly, in Q4, consumption minimization and energy savings were two undifferentiated aspects. This question clarified that "*resources*" or *energy savings* (N=12; 66.7%) could directly relate to the quite ethical attempt to save the planet's energy resources, and very often, "*for future generations*" - and less directly to the present energy consumption minimization and associated economic costs. Therefore, for this question, the two aspects were singled out. Along the same line of reasoning, there were four participants referring that energy management implementation would allow hospitals to *become environmentally* "*friendly*", such as by "*reducing Co2 emissions*". And perhaps referring to alternative and more eco-friendly energies, two interviewees specified that it would make the use of "*other*" energy sources possible.

Finally, one participant also mentioned how economic savings would allow the application of savings on other "*development*" areas (*Applying savings on other areas,* N=1), and another how it would allow hospitals to *produce rather than consume energy* (N=1) and bring *self-satisfaction* (N=1). The overall findings are presented by Figure 5-15.

Energy Management Benefits

- Minimizing consumption (N=7)
- Economic savings (N=14)
- Performance efficiency (N=8)
- Energy savings (N=12)
- Become environmentally "friendly" (N=4)
- Using "*other*" energy sources (N=2)
- Applying savings on other areas (N=1)
- Produce rather than consume energy (N=1)
- Self-satisfaction (N=1)

Figure 5-15: Energy management benefits categories (and count)

Q7: Energy savings estimates

There were eighteen managers giving their estimates for the energy savings that would be achieved by implementing energy management systems in their organization. Every participant gave a percentage, some participants gave intervals (e.g., 20%-30%), whereas two gave a minimum of savings (e.g., 20%) and one gave a maximum (50%) as an answer.

Overall, the minimum of estimated savings was 20% and the maximum was 70%. To calculate means and standard-deviations, mid-point were calculated for intervals (namely, 25% would be the mid-point of the 20%-30% interval), and minimums and maximums were accepted as final answers. This procedure yielded a mean 36.1%, a standard-deviation of 10.3% and a mode of 20% for estimated energy savings.

Simply adopting minimums and maximums as final answers and calculating descriptive statistics for lowest to highest interval value revealed a mean 34.4% to 37.8%, a standard-deviation of 11% to 10.5% and a mode of 30% to 40%, respectively. Comparing these results with those obtained with the previously described procedure suggests that the mode varied considerably according to the procedures, whereas means and standard-deviations did not. Thus, these two last statistics seemed more expressive of their overall answers.

Q8: Energy management barriers

Q8 asked respondents to select, among a set of options, which were considered barriers to the implementation of energy management systems in their organizations. Figure 5-16 shows the registered frequencies for each option.

As it can be observed, no participant claimed "*contractors*", the "*misuse of technologies*" and the existence of "*uncompleted projects*" as barriers. In addition, the "*incompatibility of infrastructures*" and the "*high maintenance and repair costs*" were chosen only once as a barrier. Nevertheless, it should be noted that the "*high maintenance and repair costs*" was an option that had to be added to accommodate for the interviewee's commentary and was not part of the original survey. Thus, it is possible that, if this option had been presented as part of the original options' set, it would have a higher choice frequency.

The most frequently chosen barriers, with a percentage of 70% or above, were: "*no good overview of existing technologies*", "*improper planning and design*", "*long process to decision making*", "*poor information*", "*energy efficiency has a low priority*" and "*lack of personal awareness*". In-between 50% and 70%, that is, still representing the majority, were: "*unwritten rules and regulations*", "*lack of trained staff*", "*high cost in replacing old technologies*", "*slow decision-making process*", "*difficulty in implementing management interventions*" and "*lack of managerial awareness*".

The remaining options ("*Difficulty in implementing technical interventions*"; "*Lack of internal technical skills*"; "*Lack of time to implement*"; "*High costs in implanting*"; "*Lack of legal framework*"; "*Conflict among departments' responsibilities*"; "*Lack of coordination between departments*"; "*Unavailability of resources*"; "*Unclear authorities in departments"*; "*Unwritten rules and regulations";* and *"Waiting for new Technology* *to be cheaper*”), though seemingly less important, should not be disregarded. Some of these options were still associated with frequencies above the 30%, thus representing more than a third of the participants’ choices, whereas others highlight different aspects that are associated with more frequent options. For example, the lack of time to implement the new systems can be partly related to the slowness or length of the decision-making process. Indeed, sometimes participants chose the three options, which, furthermore, had been presented in a row. Another example is the” *lack of internal technical skills*”, which is a more specific type of “*lack of trained staff*”, and yet represents such lack.

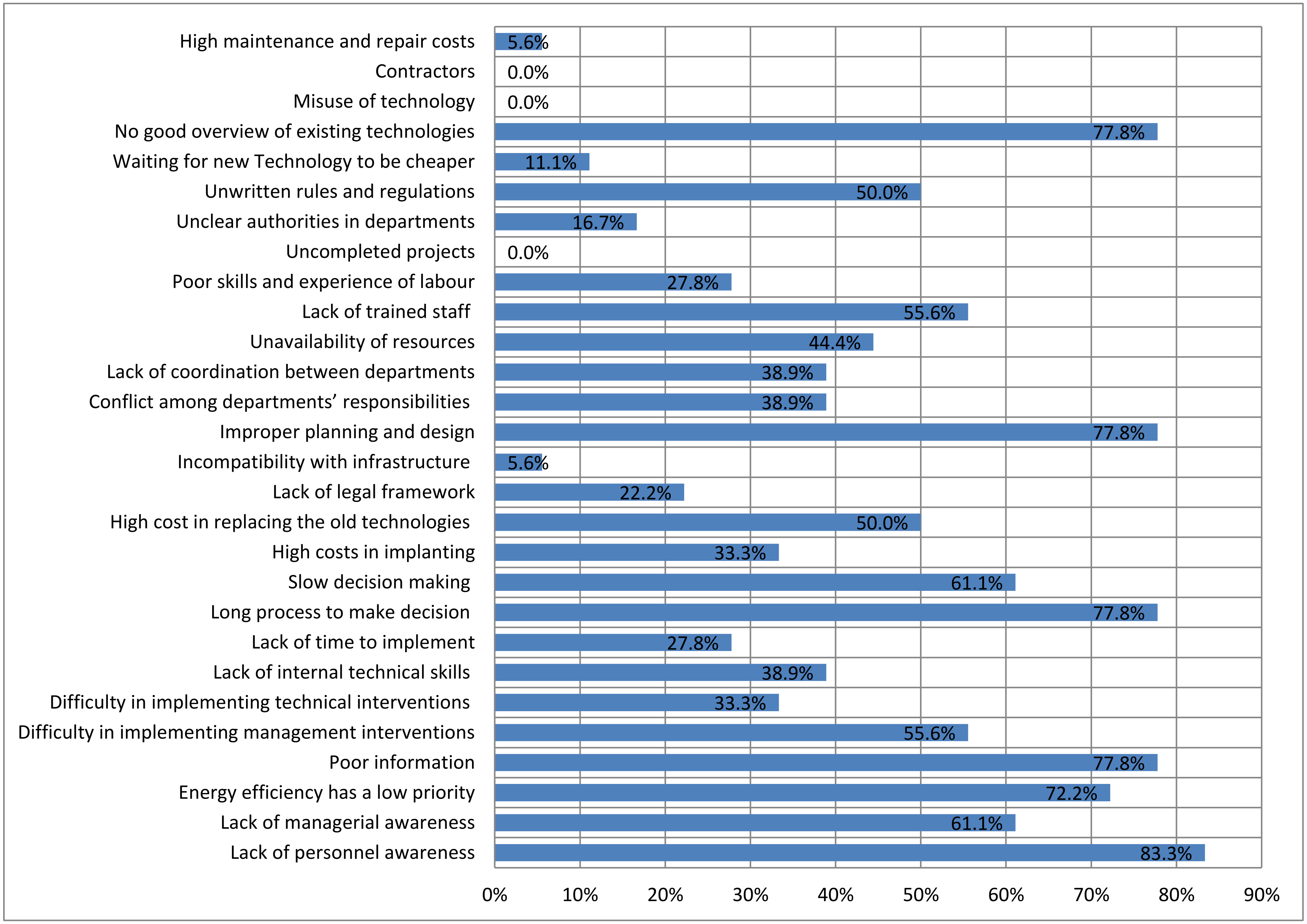

Figure 5-16: Frequencies of listed barriers to energy management systems' implementation

Q9: Barriers' risks and consequences

As it can be observed in Figure 5-17, the 18 managers considered that the barriers to the implementation of energy management systems had *negative consequences* (N=18; 100%), very friendly qualified has possessing a *great magnitude* by the use of the term "*huge*" and "*90%*" (N=13; 72.2%).

These consequences consisted of: *technical problems* (N=7); *shorter equipment life-span* (N=5); *higher consumption* (N=6); *higher costs*, such as due to higher "*energy bills*" and maintenance of equipment and devices (N=9); generally put, increased "*efforts*" (N=1); and *lower efficiency* (N=3).

In the present absence of energy systems, the *implementation* involved *efforts and difficulties* (N=4), *fixing existing designs* (N=2), *fixing systems' application* (N=2) and *making specialized staff available* (N=2). One participant also described the negative consequences as the inability to use "*cutting edge technology*" and "*contamination*". Figure 5-17 illustrates these results.

Barriers' Consequences and Risks

- Negative consequences (N=18)
- Great magnitude (N=13)
- Technical problems (N=7)
- Shorter equipment life-span (N=5)
- Higher consumption (N=6)
- Higher costs (N=9)
- Increased efforts (N=1)
- Lower efficiency (N=3)
- Implementation efforts and difficulties (N=4)
- Fixing existing designs (N=2)
- Fixing systems' application (N=2)
- Making specialized staff available (N=2)
- Fewer *"cutting edge technology"*(N=1)
- "*Contamination*"(N=1)

Figure 5-17: Barriers' consequences and risks (and count)

Q10: Existing energy efficiency standards

As it can be observed in Figure 5-18, participants were asked whether there were any followed standards for energy efficiency plans and designs in their hospitals. Half of the participants acknowledged the absence of standards (*None*, N=9; 50%) and roughly half the existence of *modified standards* (N=8; 44.4%). Some of these participants described such standards as "*general*" and not strictly concerned with energy efficiency (N=5; 27.8%), and one participant as "*old*". Five participants also provided *examples of used or modified standards*. These were: "*National Electric Code, IEC, ASHARE and IEEE*"; "*SASO and MOH*" from "*ASHARE and GCI*"; "*IEEE and ISO"; "International standards*"; "*IEEE Standard "Recommended Practice for Electrical Systems in Health Care Facilities*".

Energy Efficiency Standards

- None (N=9)
- Modified standards (N=8)
- General standards (N=5)
- Old (N=1)
- Examples of used or modified plans (N=5)

Figure 5-18: Energy efficiency standards categories (and count)

Q11: Payment responsibilities and related inter-departmental communication

Seventeen participants described the department(s) responsible for paying energy bills, as well as the inter-departmental communication and evaluation regarding these expenses. Figure 5-19 illustrates the results.

Every participant acknowledged the *Financial Department* (N=17) has responsible for paying the energy expenses. For communicating and sometimes "*checking*" the bills, sometimes those concerning special energy sources such as "*medical gases*", the role of the *Maintenance Department* (N=6) and the role of contractors (N=1) in communicating expenses to the Financial Department was also considered. The only participant commenting on existing expenses reviews said these were not practiced in the hospital.
As for inter-departmental communication, although only three respondents remarked there was *no communication*, most thought there was "*weak*", "*rare*" or *"limited" communication* (N=10; 58.8%), that mainly consisted of passing the bills to the Financial Department. That is, there usually was only an *expenses information communication purpose* (N=7). One participant also argued there were a *lack of information* and a *lack of discussion* about expenses, perhaps making a plea for their existence.

Payment Responsibilities and Communication

- Financial Department (N=17)
- Maintenance Department (N=6)
- Contractors (N=1)
- No evaluation (N=1)
- No communication (N=3)
- "Limited" communication (N=10)
- Expenses information communication purposes (N=7)
- Lack of information (N=1)
- Lack of discussion (N=1)

Figure 5-19: Payment responsibilities and related inter-departmental communication categories (and count)

Q12: Energy consumption reviews

The 18 participants shared their knowledge on current practices regarding energy consumption reviews. Two declared their lack of knowledge about their existence (*Unknown*), six the *absence of reviews* and two considered there were "*rare*", *infrequent reviews*. Nevertheless, a closer inspection of their answers suggested that their understanding of what a review varied. Namely, there were a few taking *reviews as billing information* (N=6) and/or *reviews as meter readings* (N=3). None of these understandings is incorrect, though none expresses the perspective that a review is a form of assessment and evaluation of energy spending and payments. Since every hospital has energy expenses which most probably require meter readings, those denying the existence of reviews could be referring to the later definition.

In their answers, there were *descriptions of the payment process* (N=4). In some of these answers, participants straightforwardly denied the existence of reviews. Thus, the hypothesis that payment process descriptions were always provided by participants who regarded reviews as billing information was discarded. It was further concluded that there were at least three types of understanding of what a review was. Finally, some interviewees described the *contractors in charge of meter reading and resource monitoring* (N=2). This always occurred when participants fully or partially understood reviews as meter readings. The overall results can be observed in Figure 5-20.

Energy consumption reviews

- Unknown (N=2)
- Absence of reviews (N=6)
- Infrequent reviews (N=2)
- Reviews as billing information (N=6)
- Reviews as meter readings (N=3)
- Descripton of payment process (N=4)
- Contractors in charge of readings and resource consumption monitoring (N=2)

Figure 5-20: Energy consumption reviews categories (and count)

Q13: Energy consumption and level of activity relationship analysis

Participants were asked whether energy consumption and level of activity relationship analysis were performed in their hospitals. As illustrated by Figure 5-21, from the 18 gathered answers, 1 participant acknowledged this was *unknown* by him/her and 11 (61.1%) that there were *no analysis* were conducted in their hospitals. Five remarked they *seldom* were performed, two of whom specifying such procedure occurred in special, *particular situations*. Finally, two participants described what could roughly amount to an analysis, even though one of these participants denied its existence. These were remarks about how the organizations were *starting to solve existing problems*, in particular by examining electrical loads and attempting to reduce consumption.

Consumption-Activity Analysis

- Unknown (N=1)
- No analysis (N=11)
- Seldom (N=5)
- In particular situations (N=2)
- Starting to solve existing problems)(N=2)

Figure 5-21: Energy consumption and level of activity relationship analysis categories (and count)

Q14: Energy consumption forecasts

Participants were asked about existing energy consumption forecasts. From the 18 answers, 16 (88.9%) remarked that there were *no forecasts*. The "*monthly*" occurrence of forecasts acknowledged by one participant then seems to particularly stand out as an unusual practice. There was also one participant remarking that "*maybe*" there was an existing energy consumption increase forecast, and one considering that *possibly prospectively* these forecasts would be conducted. These results are summarized in Figure 5-22.

Energy Consumption Forecast

- Unknown (N=1)
- No forecast (N=16)
- "Monthly" (N=1)
- Consumption increase forecast (N=1)
- Possibly prospectively (N=1)

Figure 5-22: Energy consumption and level of activity relationship analysis categories (and count)

Q15: Energy wastes

When asked about the existence of energy wastes in their hospitals, the 18 managers manifested the opinion that there was *existing waste* in their hospitals. The amount of waste was, to a minority, of a *medium level* (N=5) and to the majority, of a "*relatively high*", "*very*", "*huge*", or, generally speaking, of a *high level* (N=12). One or another participant further put forward what they considered as waste causes. These included: *lack of staff awareness as cause* (N=2); *older buildings as partial* cause (N=1); *others' expenses as cause* (N=1); and *not turning off lights and devices as cause* (N=1). Finally, there was also one participant adding a consumption reduction recommendation. That is, the existence of waste was associated to high energy consumption levels. These results are illustrated by Figure 5-23.

Energy Wastes

- Existing waste (N=18)
- Medium level (N=5)
- High level (N=12)
- Lack of staff awareness as cause (N=2)
- Older buildings as partial cause (N=1)
- Others' expenses as cause (N=1)
- Not turning off lights and devices as cause (N=1)
- Reduction recommendation (N=1)

Figure 5-23: Energy wastes categories (and count)

Q16: Energy consumption indicators

Participants were asked to indicate whether there were and what was the nature of the energy consumption estimates and indicators used in the hospital. From the 24 answers, four interviewees declared that there was an *indicators and estimates' absence* and one confessed this was *unknown* to him/her. The remainder indicated meter readings (N=8) and/or billing information (N=11) as the utilized estimates and indicators.

Energy Consumption Indicators

- Unknown (N=1)
- Indicators and estimates absence (N=4)
- Meter readings (N=8)
- Billing information (N=11)

Figure 5-24: Energy wastes categories (and count)

Q17: Energy contracts or agreements

Although participants had already been asked about what energy sources were utilized by their hospitals, they were also asked about existing energy contracts and/or agreements and whether these were honoured. Their answers for this question were more systematized. They generally enumerated existing *types of contracts* (N=14). These were: Maintenance (N=19); Electricity (N=14); Water (N=12); Gas (N=7); and Fuel (N=6).

That is, the most frequently acknowledged contracts were with maintenance "*operators*", with the electricity company, and with the water company. Gas and fuel were less frequently mentions, maybe because these resources are less often utilized. Alternatively, managers simply forgot to mention them. There was only one participant answering about whether the contracts were honoured by remarking that there was "*the obligation to pay bills or cutting the service*" (*Honouring contracts to prevent sanctions*, N=1).

Energy Contracts and Agreements

- Unknown (N=2)
- Types of contracts (N=14)
- Maintenance (N=10)
- Electricity (N=14)
- Water (N=12)
- Gas (N=7)
- Fuel (N=6)
- Honouring contracts to prevent sanctions(N=1)

Figure 5-25: Energy contracts and agreements categories (and count)

Q18: Technical advice

In regards to technical advice, it was: *disregarded, not followed or inexistent* (N=3); *very limitedly* followed, as expressed by terms such as "*low level*" (N=2); *limitedly* followed, as expressed by terms such as "*certain extent*", "*certain limits*", "*medium level*" or "*sometimes*"; or *considered*, as expressed by terms such as "*large extent*" or "*is considered*" (N=5). A few participants offered some reasons for seeking or following the technical advice (*Brings economic benefits*, N=4), whereas others put forward reasons for not following it, namely the existence of the more *Influential medical staff* (N=1), the fact there was *expert staff lacking* (N=2) and *communication lacking* (N=1). Figure 5-26 illustrates these results.

Technical Advice

- Disregarded, not followed or inexistent (N=3)
- Very limitedly (N=2)
- Limitedly (N=7)
- Considered (N=5)
- Brings economic benefits (N=4)
- Influential medical staff (N=1)
- Expert staff lacking (N=2)
- Communication lacking (N=1)

Figure 5-26: Technical advice categories (and count)

Q19: Commitment to follow capacities

From the 18 participants describing the hospitals' management had the commitment to follow their capacities, the majority thought that there was an *absence of commitment* (N=9) and a minority argued there was a *presence of commitment* (N=3). Only one argued such information was *unknown* to him/her. In addition, whether or not belonging to the *absence of commitment* group, the majority further offered that the hospitals were *operating above capacity* (N=9), whereas only one respondent considered that they were *operating within capacity*.

Participants were also requested to expand upon the reasons for such presence or absence of commitment and their above capacity operative mode. The causes described within these surveys were: *High demand* or reduced offer (N=14); *Service provision priority* (N=2); *Humanitarian principles* (N=6); *Population size or increase* (N=7); *Lack of hospitals' actualization*, such as via "*expansions*" (N=5); *Lack of "managerial abilities" or responsible staff* (N=3); *Lack of cost awareness or "funds"* (N=2); and *Lack of care* (N=1).

There were two answers that were worded exactly in the same way for this question. These answers gave a greater weight to the lack of hospital's actualization cause because the four emphasized such aspect. If these answers represent faulty data transpositions, then this cause would have a less overall central role for the interviewed participants.

Commitment to Follow Capacities

- Unknown (N=1)
- Absence of commitment (N=9)
- Presence of commitment (N=3)
- Operating above capacity (N=9)
- Operating within capacity (N=1)
- Causes (N=16)
  - High demand (N=14)
  - Service provision priority (N=2)
  - Humanitarian principles (N=6)
  - Population size or increase (N=7)
  - Lack of hospitals' actualization (N=5)
  - Lack of managerial abilities or responsible staff (N=3)
  - Lack of cost awareness or funds (N=2)
  - Lack of care (N=1)

Figure 5-27: Commitment to follow capacities categories (and count)

Q20: Staff awareness of energy consumption

The eighteen managers provided answers about what they thought about the staff's level of awareness about reducing energy consumption in their organizations. The levels of awareness were described as *"very low" awareness* (N=4) and *"low" awareness* (N=15). That is, there wasn't a single participant expressing satisfaction with the staff's energy consumption reduction awareness.

Fourteen respondents expanded upon what they regarded as causes for such state of affairs. These were: *information lack* (N=5), more specifically, both about "*energy*" in general or current energy "*expenses*"; *educative programs lack* (N=13), that is, the lack of existing “*training*” programs or “*education*” ; “*regulations*” or “*legislations*” lack (N=3), *awards and penalties system lack* (N=5), that an incentive that increased the staff’s “*motivation*” to change their behaviour in their energy saving attempts; expenses and energy saving valuing lack (N=4), that is, a disregard, absence of “*care*”, attention, “*rationalization*” and paying responsibilities in relation to energy matters); and specialized staff lack (N=2). An overview of these findings can be found in Figure 5-28.

Staff Awareness

- "Very low" awareness (N=4)
- "Low" awareness (N=15)
- Causes (N=14)
  - Information lack (N=5)
  - Educative programs lack (N=13)
  - “Regulations” or “legislations” lack (N=3)
  - Awards and penalties system lack (N=5)
  - Expenses and energy saving valuing lack (N=4)
  - Specialized staff lack (N=2)

Figure 5-28: Staff awareness of Energy consumption categories (and count)

Q21: Awareness promotion plan

There were 18 participants responding to whether they had awareness promotion plans. Fifteen of them have confirmed *Absence of plans* (N=15) and if there was any program for prompting energy management awareness, they can be described as seasonal or run by some hospitals. Eight of the managers think that the reasons for lack of these programs are: *lack of specialized staff* (N=6), *energy efficiency low priority* (N=5) in the healthcare and *high costs (energy management system, training funding)* (N=3). An overview of findings can be found in Figure 5-29.

Awareness Promotion Plan

- Presence of plans (the interviewee's current plan, the seasonal programs, run by some hospitals or available online, and the planned upcoming program) (N=5)
- Management and benefits information aim (N=1)
- Past energy problems cause (N=2)
- Absence of plans (N=15)
- Causes for absence of plans (N=8)
  - Energy efficiency low priority (N=5)
  - High costs (energy management system, training funding) (N=3)
  - Legislation lack (N=1)
  - Specialized staff lack (N=6)
  - Contractors support lack (N=1)
  - Effort needed (N=2)
  - Information lack (N=2)

Figure 5-29: Awareness promotion plan categories (and count)

5.5 Summary

This chapter presents an analysis for the gathered data, which was both quantitative and qualitative. The beginning of the chapter discussed the hospitals' energy matrix scores and analysed the data, which includes: 1) major electrical loads of air conditioning, boilers, water desalination stations, and medical devices; 2) the number of blackouts per year; 3) the number of successful responses to blackouts; 4) the number of backup generators; 5) the hospitals' capacity; and 6) the energy and consumption costs per year. The second part of the chapter analysed the data gathered from interviews with stakeholders in MOH in Saudi Arabia.

The next chapter will cover the discussion and relate the findings with the literature review to give recommendations for future research and achieve the aims and objectives of this research.

Chapter 6: Discussion

6.1 Introduction

Quantitative and qualitative methods were employed in this research to collect and analyse data pertinent to the research questions (RQs), which are serially expounded and answered in depth in this chapter.

6.2 RQ1: What is The Actual Overall Level of Energy Management Program and its Characteristics?

6.2.1 Level of Energy Management Program Practices

By applying energy matrix tool to assess the level of energy management practices in hospitals, and based on the answers to Q2, it seemed that the hospitals do not currently implement an energy management program, as explained in the previous chapter. Q2 put forward interesting findings associated with the possible reasons behind the existing absence of energy management and saving plans, such as lack of awareness, information, low priority and high changing costs. Existing plans were described by some interviewees as informal, possibly driven by existing energy systems' deficits, failures and/or malfunctioning relate to redistributing energy loads and implementing new devices, systems and high voltage, and aimed at reducing energy consumption. The reasons for the absence of an energy management program can be summarised as follows:

1. Lacking responsible staff.
2. Lacking proper legislation or regulation.
3. Lacking information or knowledge.
4. Lacking motivation.
5. Lacking awareness.
6. Low priority.

7. Changing and research costs and difficulties.
8. Changing non-significant savings.
9. Hospitals are public sector, thus the government undertakes to cover costs pro bono, with less emphasis on cost efficiency.

6.2.2 Energy Definition

'Energy' was defined as a source and a resource, conceptualised by many as natural or physical, rather than a resource or produced substance. Q3 further showed how the interviewees valued energy as that which allows for the production or generation of work. That gives an advantage in order to set physical limits for energy by giving a definition for energy during planning and setting goals for energy management program.

6.2.3 Energy Management Definition

Based on interviewees' responses to Q4, 'energy management' was defined as controlling, monitoring and/or managing available energy. Q4 further illustrated how the most important and consensual aspect of energy management was, for these participants, minimizing consumption and energy savings. Nevertheless, cost reduction was also important. Both of these aspects can be made synonymous with the energy management definition characteristics explained in chapter 2. This finding indicates that top management have a good understanding of energy management.

6.2.4 Energy Resources

Q5 highlighted that the hospitals considered electricity to be the main source of energy and associated behaviour was based on that. Also, Q5 highlighted that there were seemingly no relevant differences with regard to the types of energy used by the hospitals. All participants gave similar answers and mentioned the same resources. This suggests that the differences in energy consumption and associated costs are not related to the type of utilized energy. Based on their answers, an absence of renewable energy resources in the hospitals can be recognized, possibly because hospitals are not interested in engaging with the difficulties associated with sourcing and implementing green resources for energy, especially as they require high quality (i.e. stable and continuous) energy supply for biomedical and functional reasons, as explained in chapter 2.

6.2.5 Energy Management Standards

Energy matrix scores for hospitals show that the level of the energy management practices is very low. Furthermore, for Q10, participants were asked about existing standards for energy efficiency in use in their hospitals; half declared that there were none, and almost half declared the use of modified plans, which were often described as general and not concerned with energy efficiency in particular. This gives an indication that hospitals do not follow any standards related to energy management and energy efficiency standards.

6.3 RQ2: How is Energy Auditing Achieved in Hospitals and What are the Responsibilities Regarding it?

6.3.1 Energy Auditing Responsibilities

In some cases, it is a matter of perspective that makes an interviewee answer yes or no to a question. For example, for someone expecting that communication involves a bi-directional discussion of a particular matter, 'passing on the bills' could be regarded as an absence of communication. For others, the act of sending the bills, as the answers showed, is in itself viewed as a communicative act, albeit it is not sufficient to be considered an effective communication regarding energy auditing. These nuances apply to every more qualitative question herein reported upon. For this reason, the categories and their meanings were given a more central role than counts and frequencies.

As illustrated in responses to Q11, the responsibility of energy expenses belonged to the Financial Department, although contractors and the Maintenance Department were also sometimes regarded as relevant to passing along expenses information. Indeed, the existing inter-departmental expenses communication was generally described as ‘limited’ and was mainly related to informing the Financial Department about what should be paid. Q12 is a clear example of how people’s understandings of the survey questions had an influence upon their answers, and thereby these results. In particular, when confronted with the question of whether energy consumption reviews took place in their hospitals, it was possible to detect that there were at least three different opinions about what a review amounted to. Specifically, reviews were regarded as billing information, meter readings, and none of the above. In any case, an overview of their answers seemed to suggest that these reviews, when existing, consisted of billing information and/or meter readings.

The results obtained for Q16 reinforce the conclusions drawn from Q12, wherein participants were requested to comment upon existing energy reviews. This is because in both questions it is possible to observe that there is little information about energy consumption beyond meter readings and billing information. Therefore, it seemed that, when asked about more quantitative aspects of energy management, respondents always mentioned the use of these two information sources, and nothing else. Moreover, billing information was always more frequently mentioned than meter readings. In a way, the hospitals trust, at least at the light of their energy consumption monitoring procedures, the accuracy of billing information. Answers to Q12 may have links with some answers in Q2 when it was stated that there were informal plans for energy management or redistribution of energy loads. Answers to Q12 may be affected by the type of energy used, for example water is extracted from wells or produced from treatment units inside the hospitals in some locations.

For Q13, it was found that energy consumption and level of activity relationship analysis were absent in the majority of cases. Alternatively, they were infrequently conducted or their application was in its infancy. As discovered by Q14, energy consumption forecasts were even more intangible, with only one participant claiming to conduct such practices on a monthly basis, and one considering that there might be ‘one’ existing forecast.

Although there were seldom any energy consumption reviews, analyses and forecasts, every participant considered that there was energy waste, as portrayed by their responses to Q15. In other words, they had a universal impression that current organizational behaviour was wasteful (assayed to be highly and moderately so), without any empirical evidence to support such opinions.

The answers revealed that responsibilities were considered to be limited to payment purposes. Unclear and lack of authority regarding energy management and auditing could effect on many related processes, such as energy consumption information and review, identifying the relationships between level of activities and energy consumption, energy consumption forecasting and precise estimation and indication for energy consumption. It could also undermine staff performance and understanding with regard to energy management and auditing, as evidenced by answers to Q12-14 and Q16 (discussed previously).

6.3.2 Energy Contracts

Comparing the results obtained for Q5 (energy resources) with those obtained for Q17, which inquired about energy contracts, a slight frequency disparity can be observed. For example, every participant acknowledged the use of electricity for Q5, but only 77.8% identified the existence of electricity contracts and agreements. As for water, 94.4% of participants mentioned their use for Q5 and only 66.7% for Q17. Even more remarkable was the difference found for gas and fuel. For Q5, the frequencies for both energy sources were 94.4%, whereas for Q17 these were 38.9% and 33.3% for gas and fuel, respectively. Perhaps participants forgot to mention existing contracts for Q17, due to issues such as answering fatigue or lack of energy or information concerning auditing responsibilities. Also, it is important to mention that some utilities do not require contracts due to nature of some energy resources, for instance, as mentioned in the last section, some hospitals used water extracted from wells or produced from treatment units. In terms of research procedures, it is possible that the absence of randomness in sample choice might bias findings. For this reason, were this study to be repeated or expanded, a more careful sample choice procedure would be recommended. Moreover, in qualitative studies, the opinion of the minority is usually as important as the opinion of the majority, because it reveals the research object under a less frequent yet relevant and existing light. Choosing hospitals from a less important Ministry of Health category might yield useful results.

6.4 RQ3: What Are The Energy Consumption Levels and Changes Annually; What Are Types of Usages and Electrical Loads and Blackout, and The Most Significant Factors Effect on Energy Consumption?

6.4.1 Energy Consumptions

In regards to monthly energy consumption, it seems that in the second half of the year consumption was lower than in the first half of the year for every hospital. This seemed like a general pattern, despite the absence of monthly energy consumption data related to some hospitals (H3 and H4). This is a critical observation. Such absence is very important to notice because decreasing values affect total consumptions, average consumptions and standard-deviations for this hospital in particular. This absence further affects the totals, means and standard-deviations obtained for each year and across, and across years and hospitals, which has impacts on energy auditing in hospitals.

That creates many exceptional scenarios. It is impossible that no energy was spent when the reported electricity consumption equalled zero, which introduces different expected scenarios. It may be that that information was not made available or the hospitals used their own generators instead of the electricity supplier. Also, this could indicate that the hospitals were closed for those months, although even in this case some energy is usually consumed, for example for appliances that cannot be shut down. Hence, for this option to be accurate, generators would have to be under use while the hospitals were closed. However, the real scenario was that the Electricity Company was responsible for generating bills and data about energy consumption, and their procedure in generating bills is based on monthly readings for meters, taken by personnel from the company in certain appointments every month. In case of the absence of reading for meters in that selected day, the amount of consumption in the current month will be delivered and added to the next available month in which the reading is taken, even if it happened after more two months. This explains that more energy consumption can be found in the following months, which can be shown in H3 and H4 reports.

The total consumption levels were 7,326,543 kWh for year 1, and 7,818,325 kWh for year 2; across the two years this was 15,144,868 kWh. This shows a slight increase in energy consumption from year 1 to year 2. A more detailed observation of each hospital's annual consumptions showed how H3 and H5 consumed more energy for year 1; the latter consumed the most energy overall, therefore it is possible that changes were made, specifically in that hospital, to decrease energy consumption. This would explain why this hospital does not show an energy increase, in contrast to the general trend. This could also be true for H3. If the absence of data for year 1 referred to energy failures and subsequent generators use, then they might have wanted to reduce energy expenditure and prevent the re-occurrence of such problems.

As their years of experience indicated, these were generally experienced managers. This suggests that the opinions they shared in the survey are more probably empirical than theoretical and conjectural; their on-the-job observations have informed these results. Aiming to know what is truly happening or the reality of a particular context, such as Saudi Arabian hospitals, this is an advantageous choice. Qualitative speaking, the exclusive choice of top managers restricts the diversity of collected data and narrows the description of that very same reality to the viewpoint of management entities. However, given that the responsibility of introducing change and managing existing or future energy management systems would precisely belong to top managers, then such sample characteristic does not seem to bias results. Rather, the data describes the opinion of those experienced others who might more probably be concerned with the research topic (energy management).

6.4.2 Energy Consumptions per Bed

An equation was developed in this research to compare energy consumption between hospitals and to know how much each bed can consume in the targeted hospitals. The equation is constructed based on the capacity of the hospital as registered in the Ministry of Health. The equation is:

Energy Consumption of Hospital per Bed = Energy consumption (kWh) / number of beds (1)

By calculating rate of energy consumption in hospitals per bed by previous equation, it is found that the hospitals varied in their rates. For example, H1, H2 and H3 were all referral hospitals, but they had huge differences in their rates in year 2. Moreover, by comparing hospitals H1, H2 and H3 to hospital H5, a huge difference in the rate of consumption can be seen even within the same category, as shown in Table 6-1and Figure 6-1. That may indicate that there is a huge possibility for energy waste, especially in H5, or huge demand from H5 as the managers' answers to Q19 about hospitals' commitment to their capacities indicated that hospitals routinely operate over their capacities.

Table 6-1: Energy consumption per bed in hospitals in two years.

Hospital	Energy Consumption per Bed in Year 1 (kWh)	Energy Consumption per Bed in Year 2 (kWh)
H1	48843.62	52122.17
H2	4164.44	4515.56
H3	47292.30	44138.46
H4	34700	36400
H5	78904.76	62142.86

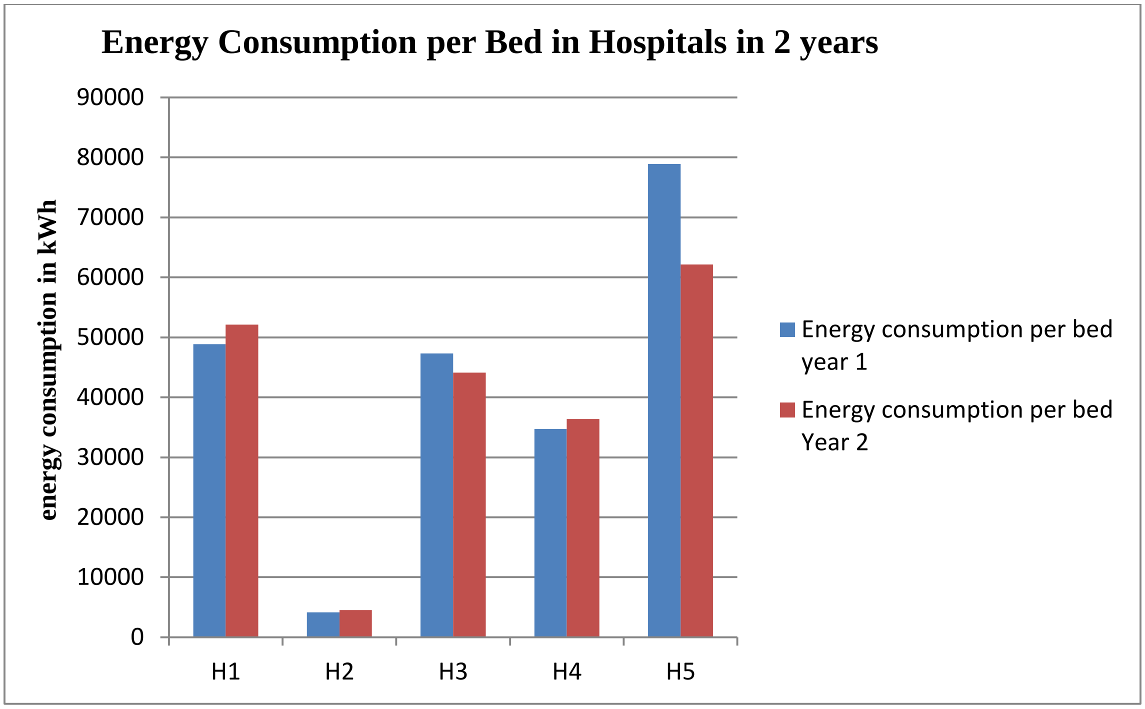

Figure 6-1: Energy consumption per bed in hospitals in two years.

6.4.3 Electric Loads and Blackouts

From collected data, it can be reported that the hospitals have heavy loads in air conditioning and medical devices. In some hospitals, biomedical devices load is the highest load. These heavy loads may be one of the reasons for suffering from electricity shutdowns, as reported in Chapter 5. By comparing this result to results in previous reports and studies explained in Chapter 2, it can be found that loads in hospitals can be different from one hospital to another hospital and from one country to another due to many factors. By considering the factors which discussed in Chapter 2 and results in this research, these factors can be summarized as:

1. Hospital size and category.
2. Population and geographical location.
3. National policies and rules.
4. Weather.
5. Type of used energy in the hospitals.

6.5 RQ4: What Are the Barriers to Energy Efficiency and to What Extent Do These Barriers Affect Energy Performance?

6.5.1 Energy Efficiency Barriers

Q8 requested participants to select barriers to energy efficiency implementation that existed in their organizations. Combining the more frequent results (above 50%) showed that the main barriers revolved around participants and overall managers' lack of awareness and the lack of information about energy management systems and existing technologies. Based on Sorrell's classification of barriers that is covered in chapter 2, the barriers in the hospitals in this research fall under behavioural and organizational perspectives. They could be overcome by providing information and thereby awareness about the topic, and thereby possibly increasing the priority attributed to such change and perhaps the motivation to better regulate energy management systems, plan and design utilized energy systems and train staff. Additional important barriers were the slowness or length of the decision making process, the difficulty in implementing managerial decisions and the high replacement costs. These barriers seem to be more related to the organizational structure and functioning, and are probably less easy to change by simply providing information and increasing awareness.

6.5.2 Energy Efficiency Barriers effects

Energy efficiency barriers were claimed to have negative consequences by every participant and very often 'huge', such as increasing costs and generating technical problems. Those risks can be summarized as:

1. Technical problems.
2. Shorter equipment lifespan.
3. Higher consumption.
4. Lower efficiency.
5. Increasing costs and efforts due to higher 'energy bills' and maintenance of equipment and devices.

It can be stated that some of these risks can be observed from collected data in this research, such as higher consumption and energy bills.

6.6 RQ5: What is the Level of Awareness of Energy Management and what are the Barriers and Drivers to promote it?

Top technical management has a good level of awareness of energy management definition, benefits, barriers to energy efficiency and their risks. However, the level of awareness of energy management was considered low in the hospitals. Answers to Q18 showed that technical advice, when existing, was more often than not followed by the hospital. The managers gave the following main reasons for the low level of awareness in hospitals:

1. Lack of education programs.
2. Lack of information.
3. Lack of awards and penalties system.
4. Lack of information on expenses and energy saving value.

As suggested by the managers' accounts for Q20, and given those reasons, the implementation of measures that addressed these aspects might increase the staff members' awareness about the importance of energy and energy saving. Some of these aspects are related. For example, educative programs could clarify energy-related issues, the importance of saving energy and how such savings could be accomplished. It could include expenses and billing information. In this way, a single measure (the offering of training courses) could fill in three mentioned gaps: lack of information; lack of educative programs; and the low estimation of the importance of cost and energy efficiency. By some simple measures, several of these requirements could be met.

6.7 RQ6: What are the Organisational Motivations for Energy Savings and Estimating the Amount of Saved Energy?

Answers to Q6 illustrated that the managers were aware of energy management benefits for their organisations, and that the most frequently mentioned benefits of implementing energy management systems were minimizing energy consumption, boosting performance efficiency, and the envisaged economic and energy savings. According to their answers to Q7, the energy savings that would be achieved by the implementation of energy management systems varied between 20-70%, with a mean of 36.1% and a standard-deviation of 10.3%. The mode seemed to be a less reliable indicator of their opinions.

6.8 Summary

This chapter has expounded on the findings derived from the literature review (Chapters 2 and 3) and the research fieldwork (Chapter 5). This and the previous chapter show that despite latent top management support, energy management practice is almost zero, and the hospitals should initiate necessary changes to improve energy management performance and energy auditing.

Reports on energy consumption in hospitals discussed in chapter 2 and the analysed data presented in Chapter 5 supports the conclusion that the hospitals may differ in their consumption and the managers should consider the types of energy consumption and the factors that affect it when initiating changes to energy management systems.

It can be concluded that key barriers to energy efficiency are mainly behavioural and organisational. These barriers can be removed and decreased by implementing organisational structure and functioning changes and providing more information. Also, the research concluded the level of awareness is low and it can be promoted by education programs and providing information about the value of cost and energy efficiency.

This chapter discussed the benefits of implementing energy management program to the hospitals from the managers’ perspectives. The next chapter presents the research conclusions and recommendations.

Chapter 7: Conclusions and Future works

7.1 Introduction

This chapter begins by reviewing the aims and objectives of this research that are discussed in chapter 1 and its expected contributions. Also, it draws the main conclusions and provides recommendations tailored to the health environment in Saudi Arabia, to help in implementing effective energy management programs. It then discusses the limitations of the research and offers recommendations for future work.

7.2 Main Conclusions

This research conducted a comprehensive literature review has been conducted to demonstrate energy management definition, benefits, standards and how to assess its level in organisations; it also illustrated energy efficiency barriers and their classification. Also, it was conducted to highlight energy consumptions reports and the attributes of energy consumption in hospitals, which helped the researcher in developing the research framework.

Two main research philosophies were used in this study, positivism and interpretivism, reflecting the mixed methods applied to achieve the research objectives. Case study was identified as the most appropriate strategy to answer the research questions. The theoretical framework was developed to address the key shortcomings of existing energy management programs and also to help the researcher provide practical guidance for implementing an energy management program in hospitals in Saudi Arabia.

Two separate but inter-related studies were conducted, aiming to better characterize energy consumption and to investigate energy management. Study A assessed the level of energy management programs and the gathering of energy consumption quantitative data from five hospitals, and study B investigated the opinions of top managers regarding energy management in their hospitals.

In study A, five hospitals were chosen based on the Ministry of Health's classification for hospitals. These hospitals represented the two major categories of hospitals in the Ministry of Health: general referral hospitals and specialized referral hospitals. An energy matrix was used to determine the level of implemented energy management programs, and the researcher also gathered details from the hospital records. Reports of energy consumption over the last two years were gathered from the energy supplier (Saudi Electricity Company).

Study B involved face-to-face, purpose-built, semi-structured interviews with eighteen top managers. The literature review explains the process behind item and question generation. The interviews were then transcribed verbatim and analysed. The interview consisted of 21 questions. It began with inquiries about the interviewees' function and experience at the hospital, and then focused on their opinions about energy management in particular.

It was found that there is a low level of energy management practices in hospitals, with no formal energy management programs being implemented. The possible reasons for this were clustered around lack of awareness, information, low priority and high changing costs. The consumption of energy in hospitals can be effected by different factors such as weather and demographic location and the policies and regulating rules. Also, the change in consumption rates can vary from country to another due to these factors. Furthermore, there are differences in the applications, activities and types of energy used in hospitals which may play a role in consumption rates.

The main barriers to energy efficiency revolved around staff and overall managers' lack of awareness and the lack of information about energy management systems and existing technologies, and considering energy efficiency to be a low priority for various reasons. These barriers seem to be more related to the organizational structure and functioning, and probably less easy to change by simply providing information and increasing awareness.

The level of energy management awareness is low due to a lack of information and educational programs, and low regard for the benefits of cost and energy efficiency. Educational programs would clarify energy-related issues, the importance of saving energy and how such savings could be accomplished. Benefits of implementing energy management systems include minimizing energy consumption, boosting performance efficiency, and the envisaged economic and energy savings. The energy savings that would be achieved by the implementation of energy management systems were estimated at a mean of 36.1%

7.3 Research Recommendations

Chapter 5 highlighted and provided details about the findings gained from the data collected in this research, and chapter 6 provided additional discussion about those findings. Based on that, the research provides significant recommendations and suggestions to support implementing effective energy management program in hospitals in Saudi Arabia for top management commitment, data and documentation and staff awareness, as discussed below.

7.3.1 Top Management Commitment

Top management should appoint a director for energy management who is responsible for setting goals for an energy management program and assessing progress and promoting awareness. This role should be supported (with restructured responsibilities and authorities) to establish a team to execute energy management activities in the hospitals. The director should spearhead the institution of a coherent energy policy, which should be integrated in workplace settings. Furthermore, the energy management team should have representatives from and working within the engineering, purchasing, operations and maintenance, contracts, building management, projects and utilities dimensions of the organisations.

Top management should study the size of problems caused by absence of energy management program and calculate the expected benefits of implementing an effective energy management program, demonstrating the high priority attached to energy efficiency and promoting awareness of this concept throughout the organisation. Accordingly, new plans and strategies should be devised for internal and external communications regarding energy management and consumption.

In terms of practical implementation of this vision, management should modify organisational structure and functions to remove or reduce energy efficiency barriers, and study possibilities for replacing high energy consuming equipment and devices with more energy efficiency alternatives (while maintaining clinical standards). Staff in all organisational levels and departments should be supported by the top management to create plans to support the overall vision of achieving energy efficiency while continuing to perform their tasks and being committed to their capacities.

7.3.2 Data and Documentation

The data should be updated and provide clear and complete information about energy use, and it should be documented electronically and made available to all relevant stakeholders, providing details about the trend and patterns of energy use in the hospitals and the type of energy used. The data should be documented by the energy department and saved in a database accessible from other departments to raise awareness of energy management and to encourage staff to save energy.

The data should show the relationship between the level of activities and the level of energy consumption, and it should be analysed, reviewed and discussed periodically among stakeholders to track changes and progress.

7.3.3 Staff Awareness

There should be educational programs related to energy issues to promote awareness of the concepts and importance of energy management and energy saving in the hospitals. Top management should drive the change, explaining to staff the benefits of energy management and risks that caused by energy efficiency barriers.

Energy expenses and billing information should be clear and accessible by the staff, to increase engagement. A guide that shows tips and information about how to save energy in hospitals should be provided to the staff to empower them to fulfil their responsibilities to achieve greater energy efficiency. Posters and pamphlets should be distributed throughout the hospitals to encourage staff and patients to save energy, and staff awareness should be promoted by designing plans for awards and penalties.

7.4 Research Limitations

This section identifies the main limitations to the research. There are three main factors that limit this research: the availability of data and resources in the hospitals, time and the authorities and permissions to access required information.

This research used semi-structured interview as a qualitative research method. Using this method can be biased due to interviewees' interpretations of situations and events. The researcher used mixed methods (quantitative and qualitative method) and triangulation technique to reduce the risk of such bias, but the potential for this cannot be completely eliminated.

This research analysed data for five hospitals and 18 interviews, which can be considered a limited (albeit broad) sample size. However, the nature of the hospitals and working in health environment where this research was conducted, and the responsibilities and profiles of the top technical managers, justify the sample size selected.

7.5 Recommendations for Future Work

Healthcare provision and its associated environments have many energy intensive requirements. People who are ill are generally viewed (by themselves and society) to have carte blanche in their use of energy – however, the massive amount of energy wasted in healthcare settings means that this sensitive and challenging problem must be faced. As this research focused on studying energy management system in hospitals, it is recommended to conduct studies to study current hospitals constructions and provide solutions to use open areas (e.g. parking areas) to implement green technologies (like solar panels) in the hospitals, and to study their economic and technical impacts. It is recommended to investigate how the policies and regulations in Saudi Arabia affect investment in green technology.

This research focused on the health sector, which is compatible with the governmental plans in Saudi Arabia and many countries to save energy. However, it is recommended to investigate about energy management performance in other high energy consuming sectors, including other state sectors such as education and military, as well as large private enterprises.

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Appendix A: Hospitals Data

Appendix A-1: Hospital H1 Energy consumption in kWh and the cost in Saudi Riyals (SR) in 24 months.

Month	Energy Consumption in kWh	Consumption per bed	Cost in Saudi Riyals
Jan	622,254	4,148.36	161,816
Feb	848,072	5,653.813	220,528
Mar	732,654	4,884.36	190,520
Apr	772,800	5,152	200,958
May	968,509	6,456.727	251,842
Jun	436,582	2,910.547	113,541
Jul	647,345	4,315.633	168,339
Aug	351,273	2,341.82	91,360
Sep	416,509	2,776.727	108,322
Oct	486,763	3,245.087	126,588
Nov	466,691	3,111.273	121,369
Dec	577,091	3,847.273	150,073
Annual Total	7,326,543	48,844	1,905,256
Average Monthly Consumption	610,545	4,070	158,771
SD Monthly Consumption	154,727.0833	1,031.514	40,229.16667
Jan	787,854	5,252.36	204,872
Feb	787,854	5,252.36	204,872
Mar	722,618	4,817.453	187,910
Apr	697,527	4,650.18	181,387
May	722,618	4,817.453	187,910
Jun	883,200	5,888	229,662
Jul	657,382	4,382.547	170,949
Aug	662,400	4,416	172,254
Sep	481,745	3,211.633	125,283
Oct	481,745	3,211.633	125,283
Nov	466,691	3,111.273	121,369
Dec	466,691	3,111.273	121,369
Annual Total	7,818,325	52,122	2,033,120
Average Monthly Consumption	651,527	4,344	169,427
SD Monthly Consumption	118206.0556	788.0404	30733.77778
Total (24 months)	15,144,868		3,938,376

Appendix A-2: Hospital H2 Energy consumption in kWh and the cost in Saudi Riyals (SR) in 24 months.

Month	Energy Consumption in kWh	Consumption per bed	Cost in Saudi Riyals
Jan	101,000	448.89	26,290
Feb	103,000	457.78	26,810
Mar	99,000	440	25,770
Apr	121,000	537.78	31,490
May	90,000	400	23,430
Jun	79,000	351.11	20,570
Jul	46,000	204.44	11,990
Aug	45,000	200	11,730
Sep	50,000	222.22	13,030
Oct	54,000	240	14,070
Nov	61,000	271.11	15,870
Dec	88,000	391.11	22,890
Annual Total	937,000	4,164	243,940
Average Monthly Consumption	78,083	347	20,328
SD Monthly Consumption	22402.77778	99.568	5825.277778
Jan	115,000	511.11	29,910
Feb	111,000	493.33	28,870
Mar	111,000	493.33	28,870
Apr	137,000	608.89	35,630
May	92,000	408.89	23,930
Jun	92,000	408.89	23,930
Jul	50,000	222.22	13,010
Aug	48,000	213.33	12,490
Sep	52,000	231.11	13,530
Oct	55,000	244.44	14,330
Nov	75,000	333.33	19,530
Dec	78,000	346.67	20,310
Annual Total	1,016,000	4,516	264,340
Average Monthly Consumption	84,667	376	22,028
SD Monthly Consumption	25000	311.11	6495
Total (24 Months)	2,890,000		752,220

Appendix A-3: Hospital H3 Energy consumption in kWh and the cost in Saudi Riyals (SR) in 24 months.

Month	Energy Consumption in kWh	Consumption per bed	Cost in Saudi Riyals
Jan	374,000	2,876.923077	97,270
Feb	0	0	30
Mar	956,000	7,353.846154	248,590
Apr	697,000	5,361.538462	181,250
May	641,000	4,930.769231	166,690
Jun	652,000	5,015.384615	169,550
Jul	783,000	6,023.076923	203,610
Aug	577,000	4,438.461538	150,050
Sep	551,000	4,238.461538	143,290
Oct	295,000	2,269.230769	76,730
Nov	294,000	2,261.538462	76,470
Dec	328,000	2,523.076923	85,310
Annual Total	6,148,000	47,292	1,598,840
Average Monthly Consumption	512,333	3,941	133,237
SD Monthly Consumption	211777.7778	1,629.059829	55062.22222
Jan	343,000	2,638.461538	89,210
Feb	465,000	3,576.923077	120,930
Mar	463,000	3,561.538462	120,410
Apr	701,000	5,392.307692	182,290
May	661,000	5,084.615385	171,890
Jun	814,000	6,261.538462	211,670
Jul	610,000	4,692.307692	158,630
Aug	419,000	3,223.076923	108,970
Sep	550,000	4,230.769231	143,030
Oct	360,000	2,769.230769	93,630
Nov	352,000	2,707.692308	91,550
Dec	0	0	30
Annual Total	5,738,000	44,138	1,492,240
Average Monthly Consumption	478,167	3,678	124,353
SD Monthly Consumption	157527.7778	1,211.752137	4,0957.22222
Total (24 Months)	18,546,333		4,823,157

Appendix A-4: Hospital H4 Energy consumption in kWh and the cost in Saudi Riyals (SR) in 24 months.

Month	Energy Consumption in kWh	Consumption per bed	Cost in Saudi Riyals
Jan	369,000	2,838.461538	95,970
Feb	348,000	2,676.923077	90,510
Mar	647,000	4,976.923077	168,250
Apr	696,000	5,353.846154	180,990
May	486,000	3,738.461538	126,390
Jun	368,000	2,830.769231	95,710
Jul	186,000	1,430.769231	48,390
Aug	186,000	1,430.769231	48,390
Sep	198,000	1,523.076923	51,510
Oct	204,000	1,569.230769	53,070
Nov	297,000	2,284.615385	77,250
Dec	526,000	4,046.153846	136,790
Annual Total	4,511,000	34,700	1,173,220
Average Monthly Consumption	375,917	2,892	97,768
SD Monthly Consumption	141888.8889	1,091.452991	36891.11111
Jan	599,000	4,607.692308	155,770
Feb	621,000	4,776.923077	161,490
Mar	586,000	4,507.692308	152,390
Apr	654,000	5,030.769231	170,070
May	453,000	3,484.615385	117,810
Jun	382,000	2,938.461538	99,350
Jul	173,000	1,330.769231	45,010
Aug	176,000	1,353.846154	45,790
Sep	0	0	30
Oct	0	0	30
Nov	0	0	30
Dec	1,088,000	8,369.230769	282,910
Annual Total	4,732,000	36,400	1,230,680
Average Monthly Consumption	394,333	3,033	102,557
SD Monthly Consumption	272,500	2,096.153846	7,0850
Total (24 months)	14,129,917		3,674,888

Appendix A-5: Hospital H5 Energy consumption in kWh and the cost in Saudi Riyals (SR) in 24 months.

Month	Energy Consumption in kWh	Consumption per bed	Cost in Saudi Riyals
Jan	1,770,000	8428.571429	460,230
Feb	1,760,000	8380.952381	457,630
Mar	1,770,000	8428.571429	460,230
Ap	2,090,000	9952.380952	543,430
May	1,460,000	6952.380952	379,630
Jun	1,500,000	7142.857143	390,030
Jul	930,000	4428.571429	241,830
Aug	850,000	4047.619048	221,030
Sep	910,000	4333.333333	236,630
Oct	1,030,000	4904.761905	267,830
Nov	1,060,000	5047.619048	275,630
Dec	1,440,000	6857.142857	374,430
Annual Total	16,570,000	78,905	4,308,560
Average Monthly Consumption	1,380,833	6,575	359,047
SD Monthly Consumption	354027.7778	1685.846561	92047.22222
13	1,690,000	8047.619048	439,430
14	1,780,000	8476.190476	462,830
15	1,540,000	7333.333333	400,430
16	1,940,000	9238.095238	504,430
17	1,430,000	6809.52381	371,830
18	1,500,000	7142.857143	390,030
19	700,000	3333.333333	182,030
20	490,000	2333.333333	127,430
21	420,000	2000	109,230
22	490,000	2333.333333	127,430
23	480,000	2285.714286	124,830
24	590,000	2809.52381	153,430
Annual Total	13,050,000	62,143	3,393,360
Average Monthly Consumption	1,087,500	5,179	282,780
SD Monthly Consumption	559166.6667	2662.698413	145383.3333
Total (24 months)	47,570,833		12,369,527

Appendix A-6: Means and Standard distributions for all hospitals in year 1 and year 2.

Year 1				
MEAN	7,098,509	1,845,963	42,781	11,125
SD	3879810.32	1008755.84	18679.04367	4856.641242
Year 2				
MEAN	5,119,971	1,331,450	30,858	8,025
SD	3419223.36	889079.68	20043.11126	5212.12943
Overall MEAN for Year 1&2	6,109,240			
Overall SD for Year 1&2	3731516.84			

Appendix B: Interview Questions

1. Could you tell me about your position and which department and your experience?
2. Do you have any initiatives or plans to implement energy management system in your organisation in the future? Why?
3. What is the definition of energy in your opinion?
4. What does "Energy Management" term mean to you?
5. What are the types (sources) for energy used in your organisation? (e.g., electricity)
6. What are the benefits from implementing energy management system for your organisation?
7. To what extend do you think you can save energy if you implement energy management system?
8. What are the barriers to implement energy management system in your organisation in your opinion? Please select more than one answer from the list below:
9. to what extend these barriers can have negative effect on implementing energy management? And what are risks if there isn't any implemented energy management program?
10. Are there any standards which are followed in planning and designing hospitals in energy efficiency? What are they, if your answer is yes?
11. Which department / departments who is responsible for energy consumption bills and reviewing it? If there is any communication between departments regarding energy consumption? (e.g., financial department)
12. How is the energy consumption reviewed?
13. Do you have an analysis identifies the relationship between consumption of energy and level of activity?

14. Is there an energy consumption forecast (predicting)? If yes, how long in advance?
15. Do you think the hospitals waste energy? if yes, could you talk more about it.
16. Do have estimations and indicators for energy consumption in your organisation? if yes, briefly what are they (meters readings- monthly bills- devices)
17. Are your agreements/contracts honoured? (such as Saudi Electricity Company) and what are they?
18. To what extend the technical advice (Doctors, Engineers, Technicians, etc.) considered in the managerial decisions? If no, why?
19. To what extend you think that the hospitals management has the commitment to follow their capacities? Why?
20. In your opinion, to which level you can consider staff awareness regarding reducing energy consumption in your organisation?
21. Do you have a plan to promote awareness of your employees (medical - technical) to energy savings in your organisation? Why?

Appendix C: Statement of Ethics Approval

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Saleh Alhurayess
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ALQURAYAT

28th May 2015

STATEMENT OF ETHICS APPROVAL

Proposer: Saleh Alhurayess

Dear Saleh,

Project Title: Analysis of Energy Management Programs in Hospitals

Under delegated authority from the College Research Ethics Committee, I have considered the application recently submitted by you. I am satisfied that there is no objection on ethical grounds to the proposed study.

Approval is given on the understanding that you will adhere to the terms agreed with participants and to inform me of any change of plans in relation to the information provided in the application form.

In addition, please provide notification to the College Research Office when the study is complete, if it fails to start or is abandoned.

Yours sincerely,

John Park
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