An-Najah National University
Faculty of Graduate Studies

Energy Management Procedures and Audit Results of Electrical, Thermal and Solar Applications in Hospitals Sector in Palestine

By
Bashar Adli Shukri Da'as

Supervisors
Dr. Imad Hatem Ibrik
Dr. Waleed Al kokhon

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This Thesis was defended successfully on 20\11\2008 and approved by:

Committee Members	Signature
1. Dr. Imad Hatem Ibrik (Supervisor)	.....
2. Dr. Waleed Al Kokhon (Co-Supervisor)	.....
3. Dr. Osama Omari (External Examiner)	.....
4. Dr. Abdelrahim Abusafa (Internal Examiner)	.....

DEDICATION

This M.Sc. thesis is dedicated to my beloved parents, my lovely brothers Dr. Samer, Dr. Ammar, Dr. Ameed, and the rest of my family members.

Acknowledgments

In such a position when one becomes incapable of expressing his noble feelings towards those who, in dedicating themselves for their great aims, were burning candles, dissipating the gloomy darkness of ignorance, and an example of those who gave without waiting for rewards.

Nevertheless, one ought to condense his appreciation in thankful sentences covering the gratitude to his noble instructors, as a token of fidelity and acknowledgment of their kindness that no paper, however wide, can contain and no pen, however ample, can suffice to describe.

Whatever their share of beautiful words and figure of speech may be, our expressions will remain incapable on fulfilling our duty towards our doctors, particularly the director of Energy Research Center, for his valuable and helpful suggestions

(Dr. Imad Hatem Ibrik)

&

(Dr. Waleed Zekaria Kokhon),

who had the major general rule and great effort in supervising this research, providing me with valuable remarks till it saw the light of day.

My heartfelt thanks to them

Eng. Bashar Da'as

الإقـــرار

أنا الموقع أدناه مقدم الرسالة التي تحمل العنوان:

Energy Management Procedures and Audit Results of Electrical, Thermal and Solar Applications in Hospitals Sector in Palestine

اقر بأن ما اشتملت عليه هذه الرسالة إنما هو نتاج جهدي الخاص، باستثناء مـــا تمـــت الإشارة إليه حيثما ورد، وان هذه الرسالة ككل، أو أي جزء منها لم يقدم من قبل لنيل أية درجة علمية أو بحث علمي أو بحثي لدى أية مؤسسة تعليمية أو بحثية أخرى.

Declaration

The work provided in this thesis, unless otherwise referenced, is the researcher's own work, and has not been submitted elsewhere for any other degree or qualification.

Student's name: **اسم الطالب:**

Signature: **التوقيع:**

Date: **التاريخ:**

Values used

Cost of one kWh = 0.73 NIS

Cost of one liter of diesel fuel = 5 NIS

Abbreviations

ASHRAE	American Society of Heating, Refrigerating and Air-conditioning Engineers
CFL	Compact Fluorescent Lamp
EC	Energy Conservation
ECO	Energy Conservation Opportunity
EMO	Energy Management Opportunity
EMS	Energy Management System
EPA	Environmental Protection Agency
EUI	Energy Utilization Index
GCV	Gas Calorific Value
GDP	Gross Domestic Product
GHG	Greenhouse Gases
IEC	Israeli Electric Corporation
JD	Jordanian Dinar
JDECO	Jerusalem Distribution Electric Company
kV	Kilovolt
kVA	Kilovolt Ampere
kWh	Kilowatt hour
LMS	Lighting Management System
LPG	Liquefied Petroleum Gas
MNIS	Million of New Israeli Shekels
MOH	Ministry of Health
MSW	Municipal Solid Waste
MVA	Megavolt Ampere
MWh	Megawatt hour
NGO	Non-Governmental Organization
NIS	New Israeli Shekel
O.H	Over Head
PCBS	Palestinian Central Bureau of Statistics
PEA	Palestinian Energy Authority
PT	Palestinian Territories
PV	Photovoltaic
R.E.S	Renewable Energy Resources
SDHW	Solar Domestic Hot Water
SPBP	Simple Payback Period
SWH	Solar Water Heater
Tep	Ton of equivalent petrol = Toe (Ton of oil equivalent)
TJ	Terra joule
Toe	Ton of oil equivalent
WBGS	West Bank and Gaza Strip

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Energy Management Procedures and Audit Results of Electrical, Thermal and Solar Applications in Hospitals' Sector in Palestine

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Supervisors
Dr. Imad H. Ibrik
Dr. Waleed Al Kokhon

Abstract

Hospitals and hospital buildings are large consumers of energy, which they use in many different ways. In this thesis we have successfully proved that there is a huge potential of energy savings in the Palestinian hospitals sector (10-25%) by implementing some energy conservation measures (no and low cost investment) on the most energy consumption equipment such as boilers, oxygen generation units, air conditioning, lighting systems, solar water heaters and others.

The efficient use of energy and energy management in Palestinian hospitals is not in a better condition than most developing countries. Thus we tried to establish a pace toward the efficient use of energy and energy management in hospitals through conducting several energy audits in some different hospitals where lighting, air-conditioning, oxygen generation units, power factor or other service levels can be reduced without detriment to comfort or health care.

We have achieved average total savings of 17% for hospitals, and 14%, 43% and 17% for cooling and heating, oxygen generation units, power factor correction and 5% for lighting systems, respectively.

Introduction

Energy conservation is a process by which the energy required to provide services within governmental and non-governmental owned and operated assets is reduced to a minimum, while achieving the required standard of service delivery.

Energy shortage is one of today's major problems. The human race faces the exhaustibility of the fossil fuel supplies upon which it has grown to depend, while the use of those fossil fuels causes major environmental pollution.

Undoubtedly, availability of reliable statistical data on energy consumption is a major input in planning and development process. Most countries pay special attention for providing statistics on energy due to the important role of energy in reflecting the situation of the infrastructure, economic situation and the level of living standards of a society. Energy statistics provide basic information on economic situation, environmental indicators and the level of living in the society [1].

The hospitals sector being one of the main energy consuming sectors in Palestine which suffer from incredible energy consumption and bad energy management validates this study, specialized in energy management procedures and audit results of electrical, thermal and solar applications in hospitals' sector in Palestine. By making rough calculations, it was found that the energy demand in Palestinian hospitals account for approximately 1% of the national energy demand in Palestine.

This thesis subject comes to highlight the importance and the need for the energy management opportunities in the Palestinian hospitals' sector, through implementing energy conservation opportunities at different high energy consuming equipments such as boilers, solar water heaters (SWH), air-conditioning, lighting, oxygen generation units and power factor improvement, in order to reduce energy consumption as a result of saving money that could be used to expand the investment and in the meanwhile, reduce environmental emissions.

Following the investigation into the literature review concerning this issue, an auditing study was made on four hospitals in Nablus city by determining the target hospitals and implementing measuring devices. Many measuring devices were used to collect the data about energy consumption in hospitals sector. All the methods depended on "no cost low cost" method.

The main idea of this work is to apply energy management procedures and audit results of electrical, thermal and solar applications in hospital sector in Palestine based on energy audits that will be provided.

The following are the research objectives:

1. To determine the potential of energy consumption in the Palestinian hospital sector.
2. To determine the potential of energy savings in different energy consuming equipments through energy audits in four different hospitals.
3. Data analysis and determination of energy conservation opportunities in

the most energy consuming equipments.

4. Establishing economic evaluation and analysis for those energy conservation opportunities.

The specific aim of the project is to optimize the energy system of the hospitals sector in order:

- To reduce energy consumption;

- To reduce pollution and CO_2 emissions;

- To reduce energy costs

- To provide energy audit and analyze energy use in hospitals sector in different areas in Palestine.

- To examine energy efficiency opportunities available for hospital.

- To make strategies to increase energy performance in hospitals sector.

- To provide specific energy saving for each energy efficiency measure based on case studies that will be provided.

The project has the purpose of achieving these goals with an integrated way that deals with technical, economic and management aspects in the same time. The thesis outline will be illustrated as follows:

In chapter one of this thesis, the energy supply and demand in the West Bank of Palestine will be discussed; Palestine imports all its needs of energy (electric and petroleum) from Israel which make the price uncontrolled. There is an increasing rate of energy demand due to the high

expansion in the residential sector and inefficient use of energy in different sectors.

In chapter two, the energy management opportunities and implementation of R.E.S in the hospital sector is presented. In boiler system, the scenarios used for increasing its efficiency such as adjusting air fuel ratio, utilization of the heat value in the combustion fuel gases and using solar energy as renewable energy source for preheating the feeding water were analyzed.

Chapter three presents the characteristics of the hospital sector in Palestine, the status of hospital sector of Palestine, and the obstacles in progress the energy management in hospitals' sector, also the energy consumption for the governmental and non-governmental hospitals are presented, finally the current situation for energy management in hospitals is discussed briefly.

Chapter four presents description of audited hospitals facilities; the annual electric and fuel energy consumption in addition to the energy bill analyses for each hospital were also discussed. For the lighting systems, three energy conservation measures were presented, removing the extra lamps, replacing existing lamps with high efficient ones and installing reflectors in the lighting fixtures.

Chapter five presents energy audit in some different hospitals in Nablus city which covers all types of hospitals in Palestine.

In chapter six the software programming of energy management opportunities is presented; we convert the most important methods employed in energy conservation in hospitals into mathematical models to pave the way for methodological designs. The flow charts for each opportunity measures, the programming design, and the verification and analysis of the program were also presented.

Finally the conclusion and the recommendations are illustrated.

CHAPTER ONE

OVERVIEW OF ENERGY SITUATION IN PALESTINE

Chapter One
Overview of Energy Situation in Palestine

The only source of 2006 was Israeli Electric Company (IEC), all Palestinian needs is imported from IEC nearly 700MW [1].

At the end of 2006, two agreements were made, one with Egypt to supply Rafah (south of Gaza) by 33kV O.H line – 17MW (connected), and the other agreement was with Jordan to supply Jericho in the West Bank by 33kV O.H line – 20MW (under construction) [1].

Most countries pay special attention to providing statistics on energy. Energy is considered of great importance due to its role in reflecting the economy, the people welfare and the level of living. Also, energy data reflect infrastructure situation. Undoubtedly, availability of reliable statistical data on energy consumption is a major input in planning and development process. There is substantial change in the economic structure and energy consumption pattern in Palestine in the last years [2]. The total energy supply is mainly from imported fuel. The utilization of available renewable energy sources like solar, biomass and wind energy is of practical importance for future socio-economic development of the country. The following sections describe the energy situation in Palestine.

1.1. Energy Supply and Demand in Palestine

In general, Palestine is considered one of the poorest countries in terms of energy resources [3]. Energy resources are either dwindling or non-existent. Indigenous energy resources are almost limited to solar energy for photovoltaic and thermal applications (mainly for water

heating), and biomass (wood and agricultural waste) for cooking and heating in rural areas. Potential of wind energy is relatively small but not yet utilized in Palestine. Biogas is also not yet utilized [3].

All fossil fuels consumed in Palestine are imported from Israel, for electricity generation, heating, transportation, cooking, operation of heavy machinery, etc. In 2002, the West Bank and Gaza Strip imported 7,128,611.1 MWh of energy, including 2,306,962 MWh of electricity, 104 million liters of gasoline, 207 million liters of diesel, 4 million liters of kerosene and 21 metric tons of oils and lubricants, (Table 1.1) [3].

Table (1.1): Imported energy in the remaining West Bank and Gaza Strip by energy type and region, 2002 [3].

Energy Type								
Region	**Electricity (MWh)**	**Gasoline (m^3)**	**Diesel (m^3)**	**Kerosene (m^3)**	**LPG (Ton)**	**Oils and Lubricants (Ton)**	**Wood & Coal (Ton)**	**Total Energy (MWh)**
Palestinian Territories	2306962	103886	207078	4301	95336	21128	3709	7128611
Remaining West Bank*	1578244	75266	106312	3285	60328	19107	3421	4554722.2
North of West Bank	403164	21902	38541	1390	27105	2163	891	1416666.6
Middle of West Bank	722412	33617	33242	898	9919	2527	125	1623333.3
South of West Bank	452668	19747	34529	997	23304	14417	2405	1514722.2
Gaza Strip	728718	28620	100766	1016	35008	2021	288	2573888.8

*** Remaining West Bank: includes all of the West Bank except for those parts of Jerusalem which were annexed following 1967 Israeli occupation.**

1.2. Energy Consumption by Sector

Statistics for energy consumption by sector show the role of the residential sector as the main energy consumer, with 38% of the total consumption in 2005.

Figure 1.1 shows the energy consumption categories in Palestine [3].

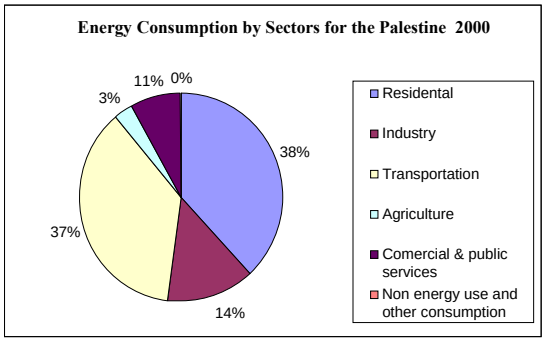


Figure (1.1): Energy consumption by sector sector for the Palestine

Energy consumption per capita for the Palestine in 2000 which is illustrated in figure 1.2 did not exceed 0.3 Toe, which is the lowest in the region. Israel's per capita energy consumption (3.5 Toe) was more than 10 times greater than the Palestinian consumption level, while that of Jordan and Syria was 3 times superior [3].

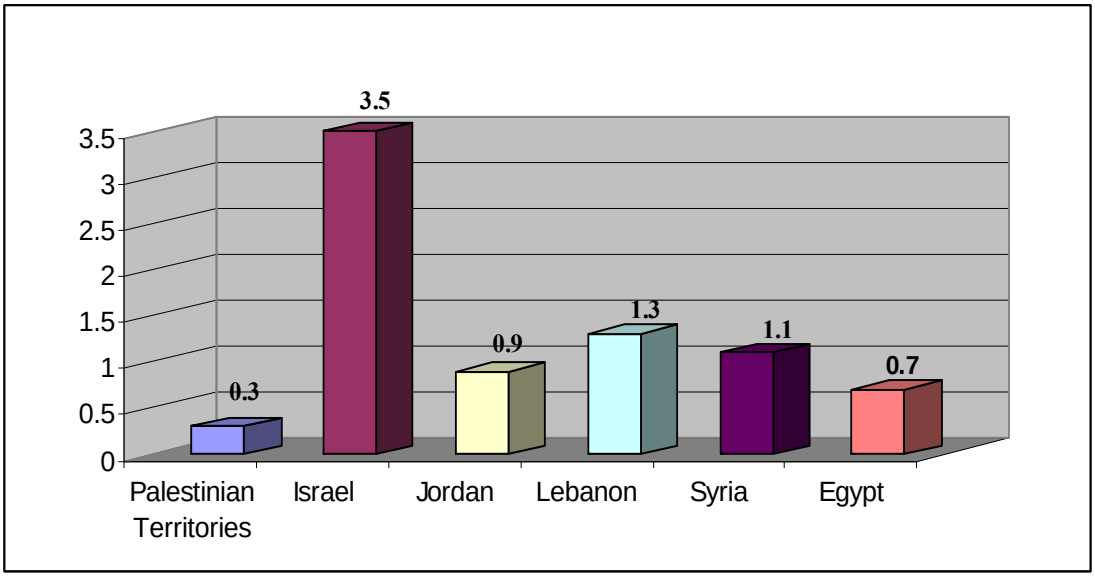


Figure (1.2) Energy consumption per capita (Toe) in 2000 [3].

Table 1.2 below summarizes the most recent comprehensive energy balance of energy supply and demand for Palestine. It shows that final energy consumption increased by 2% from 2001 to 2002, and by 9% from 2002 to 2003, despite the difficult economic conditions during this period.

Table (1.2): Summary of Energy Balance of Palestine 2001, 2002, And 2003 in (MWh) [2].

Year	2001	2002	2003
Total Energy Requirements[1]	9131388	9315000	10155278
Primary production	1719167	2437500	2812778
Imports	7401667	6881389	7330278
Energy Conversion[2]	-864167	-1065278	-1801667
Final Energy Consumption[3]	7459167	8625556	10101389
Industry and construction	593889	567500	629444
Transport	1503889	1658056	1920556
Household and other sectors	5361389	6400000	7551389

Notes: (1) Includes exports and stock changes. (2) Includes electricity generation and losses in transport and distribution. (3) Statistical differences account for the difference in data between (Total Energy Requirements less Energy Conversion) and Final Energy Consumption.

The dominance of the household and other service sectors in energy consumption means that they accounted for nearly all consumption of solar energy, LPG, olive cake and fuel wood [2].

LPG accounted for the largest proportion of energy consumption by the household and other services sectors in 2003 (29.5%), followed by electricity (26.6%), fuel wood (17.8%), solar energy (12.8%) and gas oil (9.2%). LPG is the main cooking fuel, but is also used for heating and lighting if electricity is not available in rural areas. Solar energy is used for water heating [3].

Electricity is used for lighting, refrigeration, entertainment and communications, and fuel wood is used for cooking by households that cannot afford to purchase LPG or when LPG is unavailable.

Imports of petroleum products to West Bank and Gaza have been highly correlated with GDP, (Figure 1.3). Imports of petroleum products declined by between 40% and 50% from the onset of the intifada in 2000 to 2002, and then increased from 2003 onwards.

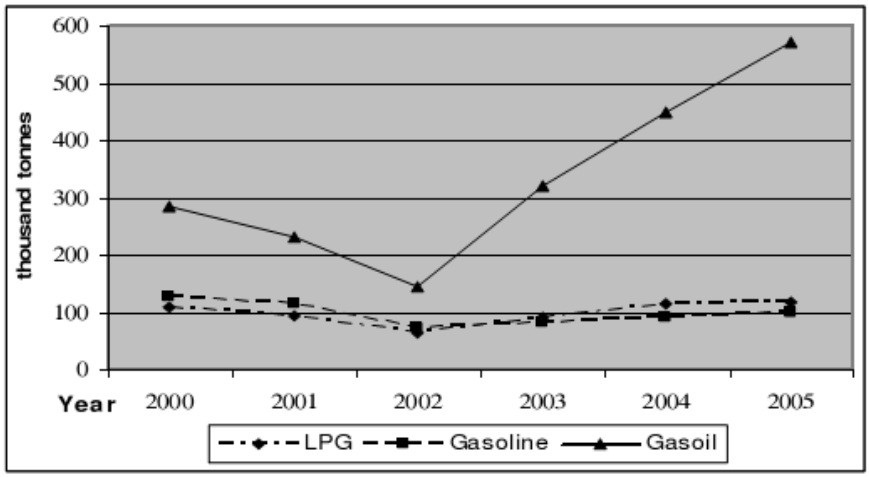


Figure (1.3): Trends in Imports of Petroleum Products to the West Bank and Gaza 2000 – 2005 [4].

The West Bank depends almost entirely on IEC for electricity supply. West Bank consumption of electricity – as measured by purchases of bulk power from IEC - increased at an average annual rate of 6.4%

between 1999 and 2005, as shown in figure 1.4. The pronounced dip in this growth that occurred in 2001 and 2002 is evidently due to the eruption of the intifada, amounting to almost 9% of purchases in 2002.

The maximum capacity of electricity supply to the West Bank is about 550MVA, 50% directly by the Israeli Electric Company (IEC) which supplies electricity in bulk to 215 towns and villages, and 40-50% indirectly by IEC through Jerusalem distribution electric company (JDECO) which supplies electricity to East Jerusalem and in bulk to 165 towns and villages in the West Bank.

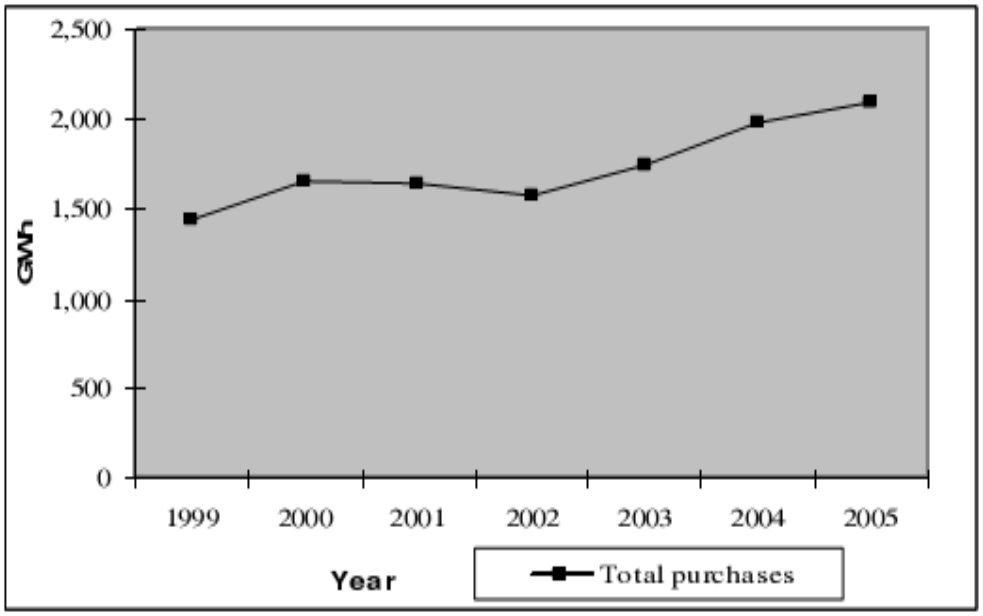


Figure (1.4): Power Purchased by the West Bank Utilities 1999-2005[5].

1.3 Energy Consumption in Hospitals Sector in West Bank

Hospitals in Palestine are classified under services institute, which is divided into two main categories, governmental hospitals, and non-governmental hospitals. The total annual energy consumption of the main 17 hospitals, which are distributed in different cities in West Bank, is

15.810 GWh\bed. Table 1.3 illustrates the total energy consumption for 17 hospitals in West Bank.

Table (1.3): Total Energy consumption in the main hospitals, 2007

Hospital	Area (m^2)	Electrical energy consumption (kWh)	Diesel Consumption (Liter)	Beds' Number
Arab specialty Hospital	2610	602652	24750	63
Bethlehem Hospital	20700	402670	23500	280
Betjala Hospital	9400	816771	105550	113
Enjeeli Hospital	2500	280256	8803	71
Ettihad Hospital	4450	370221	36000	75
Hebron Hospital	13600	1149800	78532	182
Jenin Hospital	8000	139000	31300	123
Jericho Hospital	4500	943840	13000	54
Qalqilya Hospital	500	1638	1000	10
Rafidia	7950	1186511	59000	163
Ramallah Hospital	5000	1528655	112130	155
Razi Hospital	2950	234200	105550	43
Salfeet Hospital	3600	76450	6000	35
Nalus Special Hospital	2800	426910	99200	67
Tulkarem Hospital	6800	1312000	32000	108
Watani Hospital	3000	544142	36000	119
Zaqa Hospital	2000	618000	1000	32

1.4 Overview of Renewable Energy Resources and Applications in Palestine

The lack of local oil resources generates a heavy reliance on oil imports. For these reasons, the development and use of renewable energy sources and technologies are becoming vital for the management of energy supply and demand in Palestine.

The main renewable energy resources considered to have potential in Palestine are solar energy, wind energy and biomass. Sunlight, however, biomass and biogas as well as wind renewable energy technology could be used. In considering the best R.E. alternative, it is important to consider all potential R.E. sources, their application and market availability. A review

of the energy scene in Palestine and available R.E sources is presented in this section.

1.4.1 Biomass

Although Palestine has little forest cover, it has significant other sources of biomass, namely municipal solid waste (MSW). If burnt, the 400 tons of MSW produced on a daily basis could provide 30% [5] of the electricity needs, however, due to lack of emission controls, this alternative is not being considered. As a matter of fact, in a country like Palestine with little natural resources, MSW is far more valuable if the raw material is recovered and recycled. Glass, paper, aluminum and some types of plastics are examples of material that can be completely recycled locally. Biogas generation from sewer and farm waste decomposition has the potential of offsetting 2.8% [5] of the electric needs, Animal dung is important energy material (not assessed yet). It is being used as fertilizer. More, data collection is needed [5].

1.4.2 Wind energy

Presumably, potential wind applications in Gaza are restricted to mechanical wind pumping. Wind in the West Bank, data indicates that at high mountainous elevations, annual wind speeds, may surpass 4-5 m/s [6].Table 1.6 illustrates measured average monthly wind speed based on data obtained from Energy Research Center of An-Najah University meteorological stations in north of West Bank in Nablus city [6]. This means that the uses of wind energy is applicable for small scale electricity generation, battery charging and perhaps even wind diesel systems and

water pumping. However, there are no such applications in the West Bank at present.

Table (1.4): Monthly wind speed in Palestine, 2005[6]

Mon.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	**Yr. ave.**
Wind Speed m/s	4.97	4.93	4.59	4.82	4.27	4.25	4.23	4.31	3.95	4.7	3.46	3.61	**4.34**

1.4.3 Solar energy

Palestine is considered as a country of high solar energy potential since the daily average of solar radiation intensity amounts to 5.4 kWh/m^2-day. Furthermore, the annual average of total sunshine duration amounts to 2850 h. In addition, it should be emphasized that the daily average of solar radiation intensity during the period from the beginning of April to the end of September varies in the range from 6 to 7.8kWh/m^2-day and differs in the range from 2.8 to 5 kWh/m^2-day during the remaining period [6].

Figure 1.5 illustrates measured daily average insolation (Wh/m^2) for each month based on data obtained from Energy Research Center of An-Najah University meteorological station located in Tulkarm city in Palestine [6]. These figures are very encouraging to exploit this energy as far as possible.

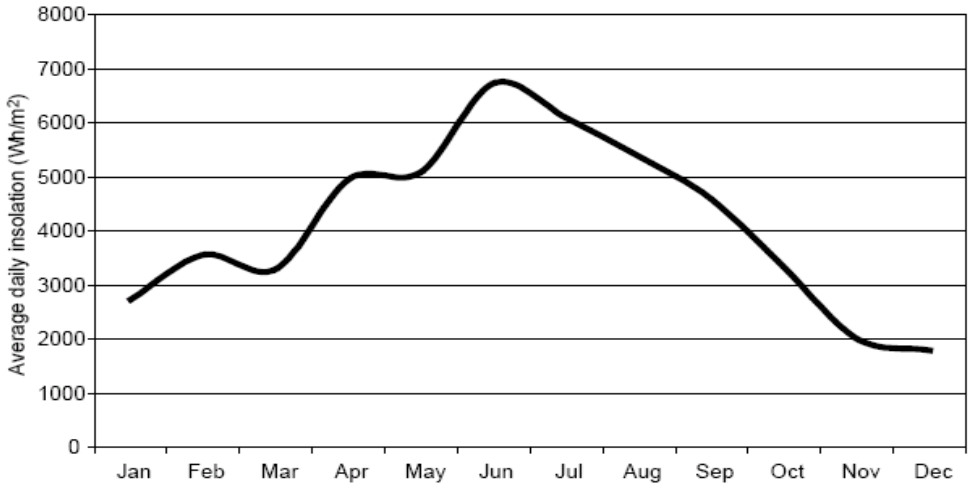


Figure (1.5): Daily average solar insolation throughout the year 2006 [6].

However, guaranteeing of economic feasibility depends mainly on selecting the appropriate application and on design of the solar system. Exploiting of solar energy occurs through converting it into thermal energy which is used in water heating, space heating and drying of vegetables and fruits. Solar energy can be also converted into electric energy by photovoltaic cells.

1.4.4 Solar PV

With the majority of towns and villages connected to the electric grid, solar PV in its current status is not economical and cannot compete with electricity supplied with the traditional methods. An exception exists for isolated remote applications such as transmission and relay towers.

1.4.5 Solar thermal

Due to its abundant solar resources and the maturity of the solar thermal industry, Palestine stands to benefit greatly from the utilization of solar water heating. Domestic solar water heating DSWH is widely used in Palestine. They were introduced to Palestinian market from Israeli market

in the sixties. Nowadays, more than 70% of households in Palestine are utilizing solar energy by using solar water heaters [7]. This percentage differs within the Palestinian region. Figure 1.7 shows the percentage of households in Palestine using solar water heaters by region in 2005. The total area of installed SWH in Palestine is more than 1,500,000 square meters. Figure 1.6 shows the increasing use of S_HW systems [7].

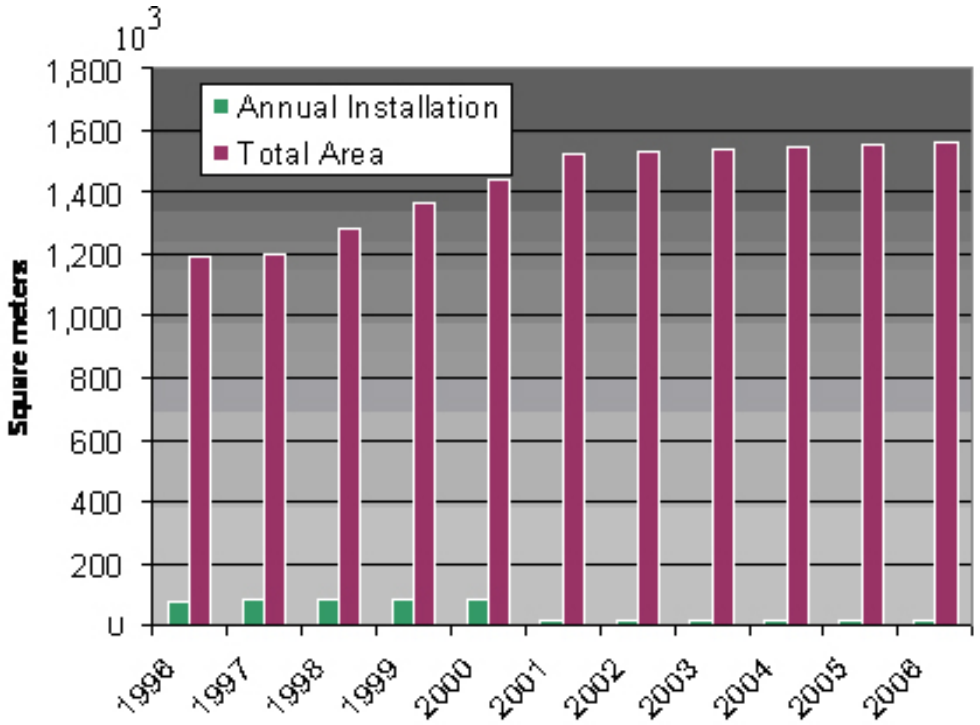


Figure (1.6): Annual Installation of SWH Systems in Palestine

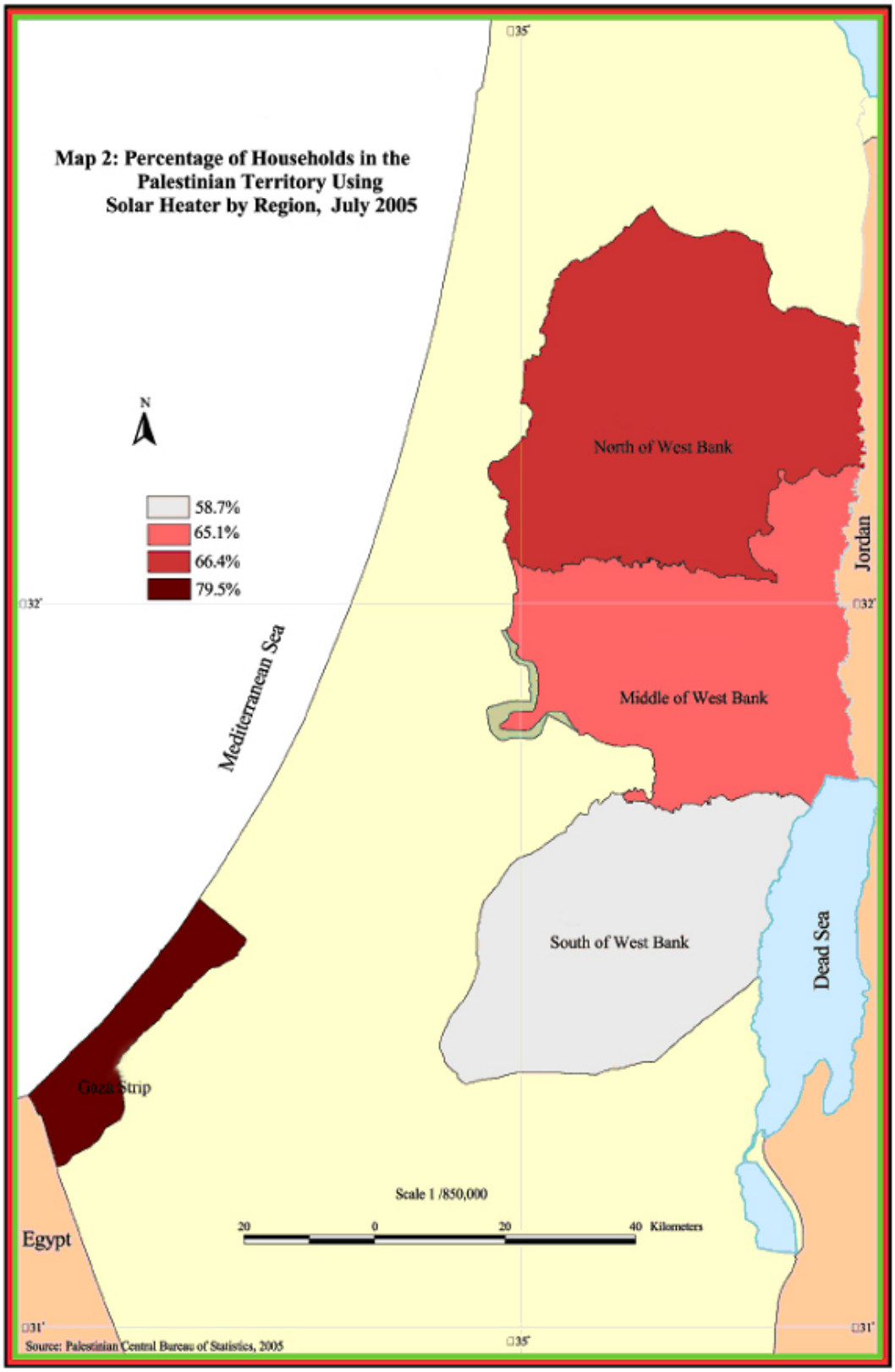


Figure (1.7): Percentage of households in Palestine using solar water heaters by region: 2005 [7]

1.5 The Situation of Electrical Energy in Palestine

The national independent power system is still under construction and rehabilitation. There is limited electrical power generation capacity in Palestine as most of the required electrical power is supplied by Israeli Electric Corporation (IEC). However, recently, Palestinian Authority has performed many electrification and rehabilitation projects, such as the rehabilitation of 70% of the Gaza network ($23 million, Norwegian aid). Thanks to donors from various European countries, electrification of the Gaza industrial estate and rural electrification in the West Bank have been possible, as well as the construction of an electricity station in Gaza with a generation capacity of 140MW at the first phase. This station is now partially operational producing one third of its full capacity. The main source of fuel for this station was supposed to be natural gas, but due to political obstacles which caused the halting of the project for production of natural gas from Gaza sea, the station uses diesel for energy.

The current situation shows how the Palestinian energy sector is still dependent on Israel. Thus, the electrical networks in Palestine are all considered as distribution networks. The voltages of these networks are 400V, 6.6 kV,11 kV, 22 kV, and 33 kV. IEC supplies electricity to the electrified communities by 33 or 22 kV overhead lines. Electricity is purchased from IEC and then distributed to the consumers [8].

The largest company in the West Bank is Jerusalem Electricity Company (JEC); it supplies electricity to around 120,000 consumers that serves 500,000 inhabitants. The municipalities of Nablus, Hebron, Jenin, Tulkarem and Qalqiliah are supplying electricity to around 92,000

consumers that serves about 435,000 inhabitants and the others from disel generators. The peak load and energy consumption in the main districts of Palestine has been estimated as shown in Table 1.5[8].

Table (1.5): Peak load and energy consumption in the main districts of Palestine

Area/district	Peak load (MW)	Energy purchased (kWh/year)
Jenin	13	45,947,520
Tulkarem	15	55,237,520
Nablus	55	161,818,065
Qalqiliah	10	37,946,083
Jerusalem	185	801,345,285
Gaza	220	701,107,000
Hebron	60	190,674,520

The electricity network is considered to be a serious problem for Palestine, because it is characterized by high electricity loss in addition to frequent power cuts. Moreover, the inadequate network causes a supply shortage for the industrial sector, while the proportion of the cost of electricity is very high (nearly 35% of the operation cost) [8].

1.5.1 Electricity consumption

Palestinian per capita consumption is considered the lowest in the region. Remarkable decline in electricity consumption since Sept/2000 (2nd Intifada) per person was 675 kWh/year compared to 5200 kWh/year for Israel as a result of negative growth rate of the domestic product and the high level of poverty as shown in table 1.6 [9].

Table (1.6): Consumption Per capita kWh/ year 2006

Consumption Per capita kWh/ year 2006	675	5200	1145	2100	1050
Country	Palestine	Israel	Jordan	Lebanon	Egypt
Average of Arab countries: 1445 kWh/capita/year					

Statistical studies on electricity growth and energy demand in Palestine illustrate a sharp increase in electrical energy consumption with an annual average growth of 10% in the years 1994-1998. It is also expected that power capacities will be increased in the next 10 years due to the national development in all sectors. However, recent studies show a remarkable decline in electricity consumption since the beginning of the **Intifada** in September 1999 (Fig. 1.8). It is obvious that political instability reduces the marginal consumption level. This can be explained by the negative growth rate of the GDP, the low level of employment and the high level of poverty.

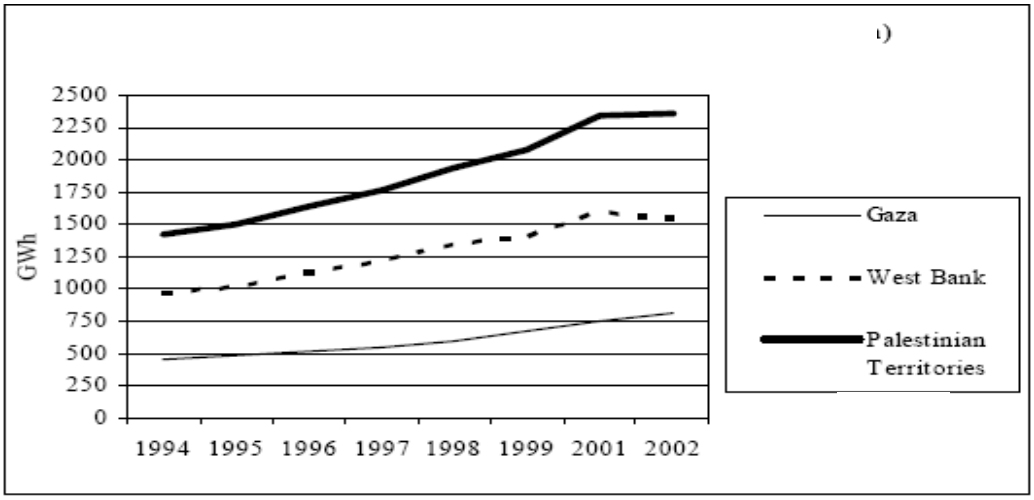


Figure (1.8): Electricity consumption in the Palestine (GWh): 1994-2002 [12].

1.5.2 Electricity consumption by use

Electricity utilization is considered essential not only for the hospital residential and services sectors, but also for water pumping and street lights. Data from the Palestinian Energy Authority for electricity consumption indicates that the residential sector consumes 61% of the total electricity 22% commercial sector, 11% for services sector Electricity consumption for both water pumping, and for street lights is 2%. (Fig. 1.9).

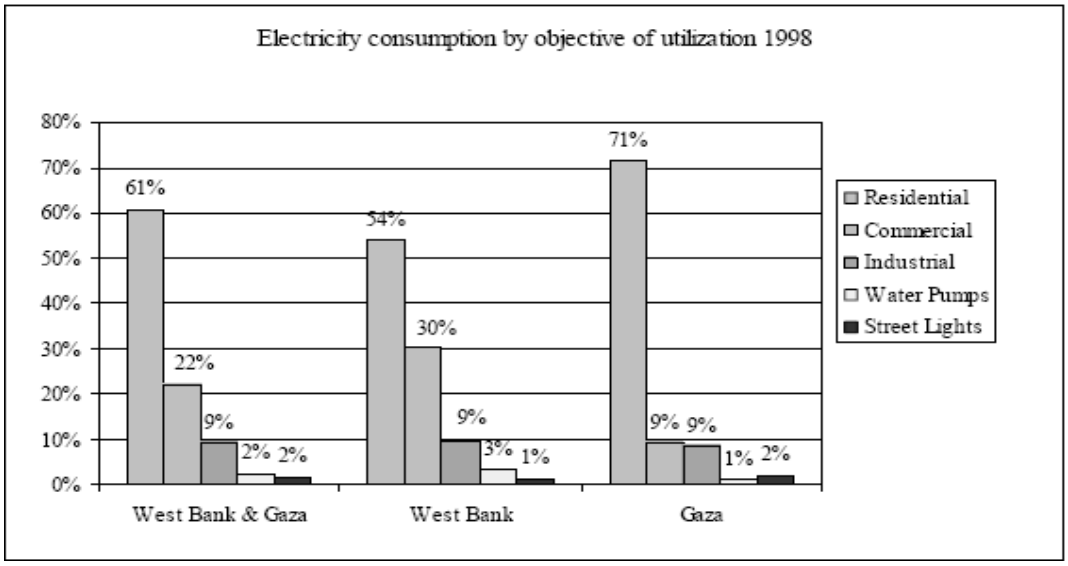


Figure (1.9): Electricity consumption by objective of utilization: 1998 [12].

1.5.3 Electricity imports

As mentioned earlier, the Palestine is completely dependent on electricity imports from Israel. The following figure shows electricity imports at different periods during the same year.

Except during the periods of high electricity needs, notably for heating in winter and air conditioning in summer, electric imports did not fluctuate much in function of different periods in the year. This shows a moderately stable attitude toward electricity uses (Fig 1.10).

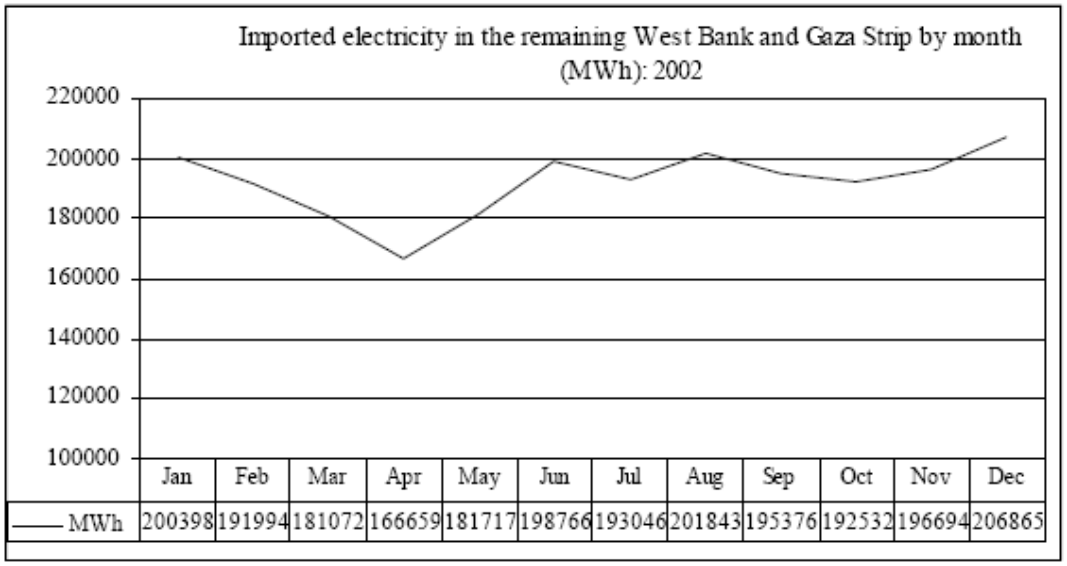


Figure (1.10): Imported electricity in the remaining West Bank and Gaza Strip monthly [11].

Electricity is not, however, the only source of energy; LPG can be considered an alternative source for electricity for certain uses and it already has a wide acceptance in the Palestinian Territories , especially for space heating and water heating (Fig. 1.11).

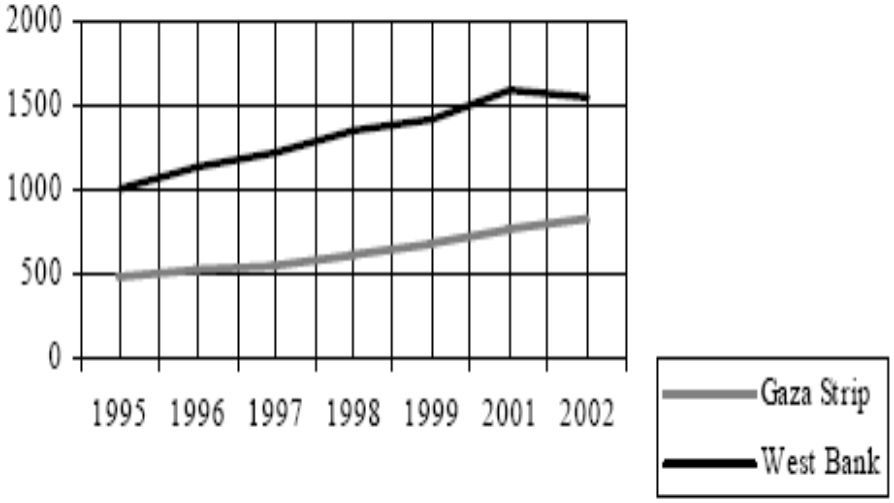


Figure (1.11): Total LPG consumption [12].

1.5.4 Electricity prices

The fact that electricity production is monopolized by the IEC imposes high prices; thus subsidizing the Israeli industrial sector with up to $100 million (1997) [8].

One of the main problems, other than transmission losses, is the high price of electricity. Energy prices in Palestine are very high compared to international prices such as in Israel 0.65 NIS and in Jordan 0.4 NIS. Table 1.7 shows the prices of different energy sources in Palestine.

Table (1.7): Consumer energy prices in Palestine 2005 [13].

Price of Electricity	0.73 (NIS/kWh)
Price of Gasoline	6.5 (NIS/liter)
Price of Diesel	5 (NIS/liter)
Residual Fuel Oil #6	4.5 (NIS/liter)
Price of Kerosene	5 (NIS/liter)
Price of Firewood	450 (NIS/ton)

CHAPTER TWO

ENERGY MANAGEMENT OPPORTUNITIES AND IMPLEMENTATIONS OF RENEWABLE ENERGY RESOURCES IN HOSPITALS' SECTOR

CHAPTER TWO

Energy Management Opportunities and Implementations of Renewable Energy Resources in Hospitals Sector

2.1 Energy Management Opportunities (EMO)

All hospitals and hospital buildings are unique in design, size, in addition to different specialized services they provide. Their technical system must be designed and adjusted to meet the requirements and needs of each individual environment. Most hospitals have no regulations that outline how these requirements may be fulfilled, through proper design and operation of technical systems, and also of the building itself.

The energy management is a systematic on-going strategy for controlling a building's energy consumption pattern. It is meant to reduce waste of energy and money to the minimum permitted by the climate where the building is located, its functions and other factors. It establishes and maintains an efficient balance between a building's annual functional energy requirements and its annual actual energy consumption.

The value of energy management in hospitals, in a wider sense, and energy management, can be described as a way of improving the energy efficiency in an existing building by continuously striving towards decreased energy consumption. This includes operating and maintaining the building in a way that sustains the energy efficiency gains achieved. In Palestinian hospitals, there are many energy management opportunities.

The primary objective of energy management is to maximize gains or minimize costs. Some desirable sub objectives of energy management programs include:

1. Improving energy efficiency and reducing energy use, thereby reducing costs
2. Cultivating good communications on energy matters
3. Developing and maintaining effective monitoring, reporting, and management strategies for wise energy usage
4. Finding new and better ways to increase returns from energy investments through research and development
5. Developing interest in and dedication to the energy management program from all employees
6. Reducing the impacts of curtailments, or any interruption in energy supplies

Significant energy and savings are available through energy management. Most facilities (hospitals, schools, office buildings, etc) can save according to three categories:

1. Low cost activities first year or two: 10 to 20%.
2. Moderate cost, significant effort, three to five years: 15 to 30%.
3. Long-term potential, higher cost, more engineering: 30 to 50%.

Thus, large savings can be accomplished often with high returns on investments and rapid paybacks [14].

The strategies for achieving energy savings in hospitals are quite different from those for most other sectors. Hospitals are generally

receptive to efforts to cut their energy costs, but less likely to be attractive to regulatory measures that increase their operating costs.

The technical options available for energy savings in hospitals' sector are as diverse as the hospitals themselves. However, they principally revolve around the saving of energy in areas such as:

- Boilers efficiency
- Solar water heaters
- Air-conditioning system
- Lighting system
- Oxygen generation unit
- Power factor improvement

Each system will be analyzed and discussed separately from the energy management potential opportunity point of view.

2.1.1 Energy Conservation in Lighting Systems

Managers in hospitals is seeking technologies or methods to reduce energy expenses and environmental impact. Because nearly all buildings have lights; lighting retrofits are very common and generally offer an attractive return on investment. Electricity used to operate lighting systems represents a significant portion of total electricity consumed in hospitals. Fluorescent lamps, compact fluorescent lamps (CFL) and incandescent

lights are typically used for task lighting and offices in hospitals. The two objectives of the lighting designer are:

(1) to provide the right quantity of light, and

(2) Supply the right quality of light

Reducing energy in the lighting systems is not expensive. Following are some of those opportunities.

- **Reducing The Number of Lighting Lamps:** This can be arranged by measuring the illumination level at the specific area and comparing it with the international standards for illumination, this measure saves a good percentage of energy especially that when you remove a lamp, you remove also its ballast that consumes energy.

- **Install High Efficiency Lighting Lamps**: The efficient fluorescent lamp lasts roughly ten times longer than an incandescent light and is three times more effective and consumes less [15].

- **Install Reflectors in Light Fixtures:** Reflectors are highly polished "mirror-like" components that direct light downward, reducing light loss within a fixture. Reflectors can minimize required wattage by using less more effectively ones [15].

2.1.2 Energy Conservation in Boiler Systems:

Boilers mainly used in hospitals for space heating and for hot water, so raising performance of the boiler, like efficiency, have many economical and environmental benefits; we will illustrate standard methods of

measuring efficiency that help us to find out how far the boiler efficiency drifts away from the best efficiency.

The cost of boiler fuel is typically the largest energy cost of a facility, or the second largest. For this reason, a relatively small efficiency improvement in the boiler plant may produce greater overall savings than much larger efficiency improvements in individual end users of energy. Also, most boiler plants offer significant opportunities for improving efficiency [16].

The various energy efficiency opportunities in the boilers system can be related to combustion, heat transfer, avoidable losses, high auxiliary power consumption, water quality and blow down. The main efficiency measures are the fowling:

1. Boiler-Excess Air Control

Operating boiler with an optimum amount of excess air will minimize heat loss up the stack and improve combustion efficiency. Combustion efficiency is a measure of how effectively the heat content of a fuel is transferred into usable heat. The stack temperature and flue gas oxygen (or carbon dioxide) concentrations are primary indicators of combustion efficiency.

Given complete mixing, a precise or stoichiometric amount of air, is required to completely react with a given quantity of fuel. In practice, combustion conditions are never ideal, and additional or “excess” air must be supplied to completely burn the fuel.

The correct amount of excess air is determined from analyzing flue gas oxygen or carbon dioxide concentrations. Inadequate excess air results in unburned combustibles (fuel, soot, smoke, and carbon monoxide) while too much results in heat lost due to the increased flue gas flow—thus lowering the overall boiler fuel-to-steam efficiency.

There is an optimum level of excess-air operation for each type of burner or furnace design and fuel type.

Only enough air should be supplied to ensure complete combustion of the fuel, since more than this amount increases the heat rejected to the stack, resulting in greater fuel consumption for a given process output [17].

Typical optimum levels of excess air normally attainable for maximum operating efficiency are indicated in Table 2.1 and classified according to fuel type and firing method [17].

The amount of excess air (or O_2) in the flue gas, unburned combustibles, and the stack temperature rise above the inlet air temperature are significant in defining the efficiency of the combustion process. Excess oxygen (O_2) measured in the exhaust stack is the most typical method of controlling the air-to-fuel ratio. However, for more precise control, carbon monoxide (CO) measurements may also be used to control air flow rates in combination with O_2 monitoring. Careful attention to furnace operation is required to ensure an optimum level of performance.

Table (2.1): Typical Optimum Excess Air [17]

Fuel Type	Optimum Excess Air %	Equivalent O_2 (by Volume)
No.2 Oil	10-15	2-3
No.6 Oil	10-15	2-3

Figures 2.2 and 2.3 can be used to determine the combustion efficiency curve for reducing excess air of a boiler fired system burning No. 2 fuel oil, or No. 6 fuel oil respectively so long as the level of unburned combustibles is considered negligible [17].

The more air is used to burn the fuel, the more heat is wasted in heating this air rather than in producing steam. Air slightly in excess of the ideal stoichiometric fuel/air ratio is required for safety, and to reduce NOx emissions, but approximately 15% is adequate [13]. Poorly maintained boilers can have up to 140% excess air, but this is rare. Reducing this boiler back down to 15% even without continuous automatic monitoring would save 8% of total fuel use. A rule of thumb often used is that boiler efficiency can be increased by 1% for each 15% reduction in excess air or 40°F (22°C) reduction in stack gas temperature [16].

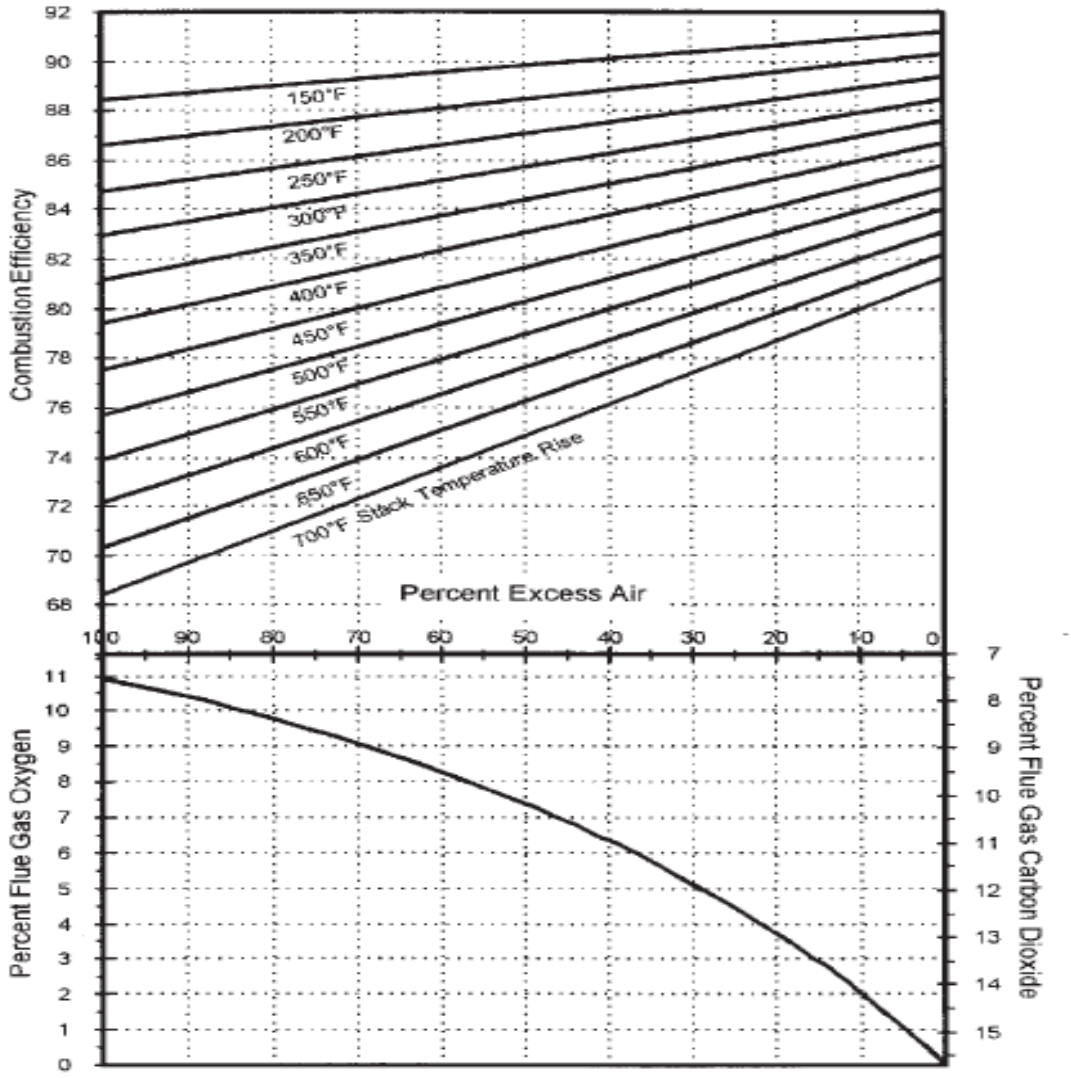


Figure (2.1): Combustion efficiency chart for number 2 fuel oil [17].

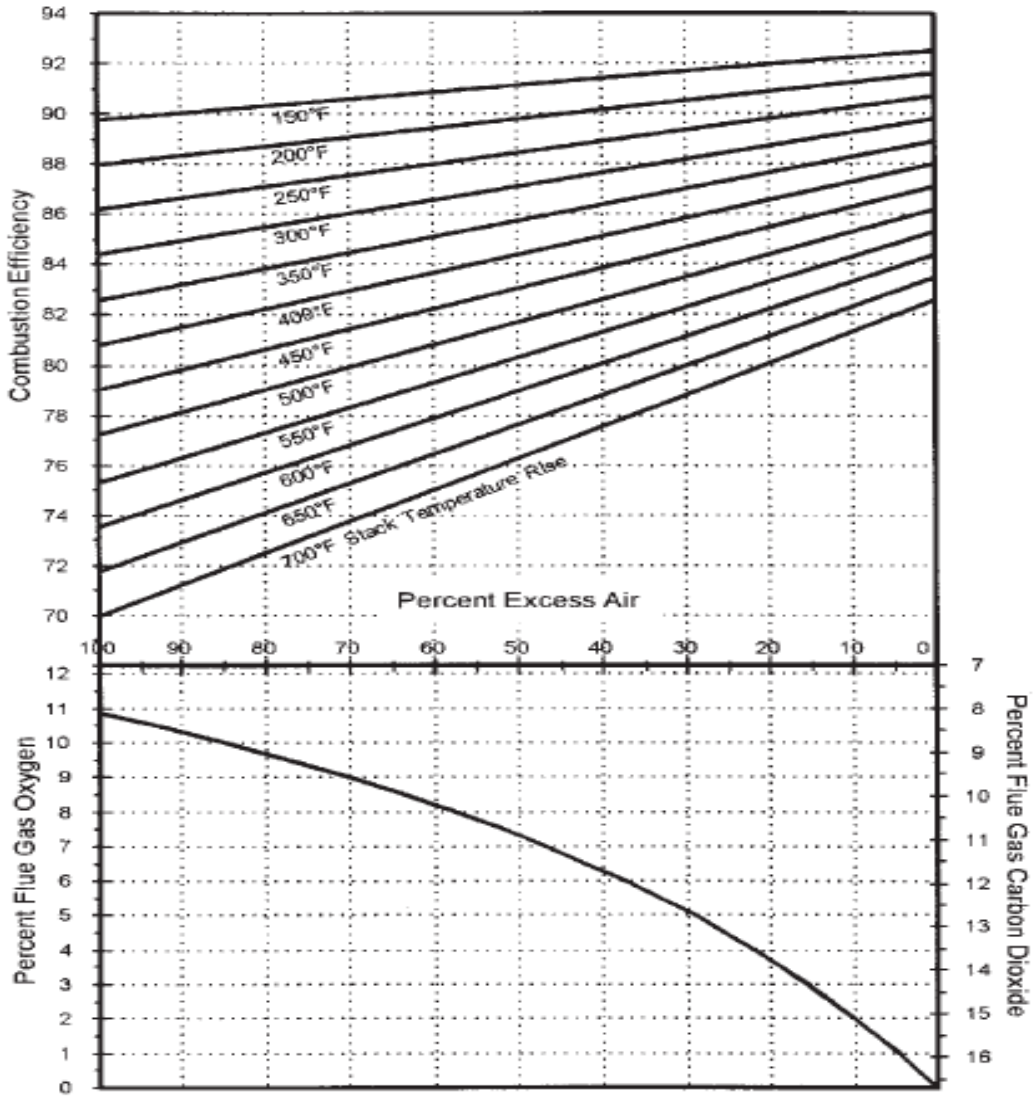


Figure (2.2): Combustion efficiency chart for number 6 fuel oil [17].

Although we can calculate the fuel saving from the following equation:

$$\text{Savings in Fuel} = \text{Fuel consumption}\left[1 - \left(\frac{\eta_1}{\eta_2}\right)\right] \quad \text{.....2-1}$$

Where: η_1: The old efficiency

η_2: The new efficiency after improving

2. Boiler Maintenance:

"Boiler operation and maintenance are closely tied together. Good operation includes performing necessary daily and periodic maintenance. Low maintenance cost depends on good daily operating control; the system and fuel are compatible. A simple maintenance program to ensure that all components of the boiler are operating at peak performance can result in substantial savings. In the absence of a good maintenance system, the burners and condensate return systems can get out of adjustment. These factors can end up costing a steam system up to 20-30% of initial efficiency over 2-3 years. They estimate a 10% possible energy savings on average" [15]. Improved maintenance may also reduce the emission of criteria air pollutants.

The basic components of a boiler are shown schematically in figure 2.3

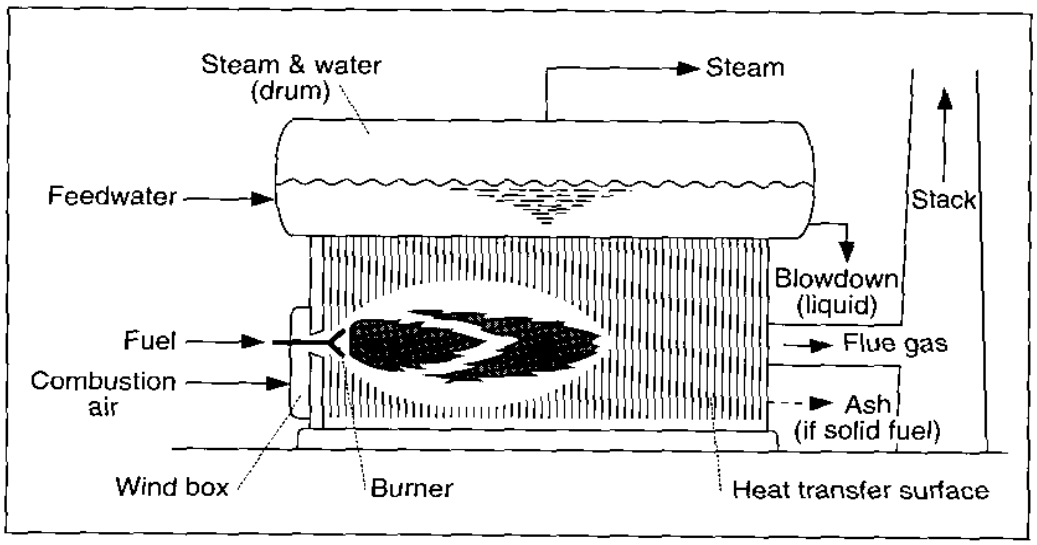


Figure (2.3): Simplified schematic of basic boiler components [15]

After all, “Preventive maintenance” gets its name because it averts the sort of problems you want to avoid. It's important to perform preventive maintenance on an established schedule [18].

3. Boiler - recover heat from flue gas:

Another primary factor affecting unit efficiency and ultimately fuel consumption is the temperature of combustion gases rejected to the stack. Increased operating efficiency with a corresponding reduction in fuel input can be achieved by rejecting stack gases at the lowest practical temperature consistent with basic design principles.

In general, the application of additional heat recovery equipment can realize this energy conservation objective when the measured flue-gas temperature exceeds approximately 250°F [19].

2.1.3 Energy Conservation in Cooling Systems:

The use of air-conditioning in the hospitals presents many problems not encountered in less demanding types of building. The space cooling system in the hospitals operated by electrical energy covers about half of the total volume.

The energy consumption by this system could be estimated by taking the difference of average energy consumption between two seasons or by measuring the total consumption of the air-conditioning systems. Saving can be achieved in cooling systems by controlling the thermostat at 22 ºC.

Percentage of saving in cooling system in summer season is calculated as the following equation:

Energy saving = $[(T_{existing} - T_{out}) - (T_{suggested} - T_{out})] / [(T_{existing} - T_{out})]$....**2.2**

Where

$T_{existing}$: The temperature inside the room

T_{out}: Before cooling the space

$T_{suggested}$: Suggested room temperature

2.2 Power Factor Correction

Low power factor is expensive and inefficient. Many utility companies charge you an additional fee if your power factor is less than 0.92 low power factor also reduces your electrical system's distribution capacity by increasing current flow and causing voltage drops.

Power factor, which is defined as the ratio of real (working) power in kW to apparent (total) power in kVA

$$P.F = \frac{\text{Real Power (P)}}{\text{Apparent Power (S)}} \quad \ldots\ldots\ldots\ldots\ldots\ldots 2.3$$

Low power factor is caused by inductive loads (such as transformers, electric motors, and high-intensity discharge lighting), which are a major portion of the power consumed in hospitals. Unlike resistive loads that create heat by consuming kilowatts, inductive loads require the current to create a magnetic field, and the magnetic field produces the desired work. The total or apparent power required by an inductive device is a composite of the following:

• Real power (measured in kilowatts, kW)

- Reactive power, the nonworking power caused by the magnetizing current, required to operate the device (measured in kilovars, kVAR)

Reactive power required by inductive loads increases the amount of apparent power (measured in kilovolt amps, kVA) in your distribution system. The increase in reactive and apparent power causes the power factor to decrease.

Some of the benefits of improving your power factor are as follows:

- The consumption in hospitals sector will be decreasing. Low power factor requires an increase in the electric utility's generation and transmission capacity to handle the reactive power component caused by inductive loads. Low power factor will charge a penalty fee to customers with power factors less than 0.92. The hospitals can avoid this additional fee by increasing the power factor.

- The hospital electrical systems branch capacity will increase by reducing the current drains from the network, so uncorrected power factor will cause power losses in distribution systems.

2.3 Implementation of Solar Energy for Thermal Applications

In the hospitals sector, hot water needs are continuous and significant in quantity.

Although there is wide variation between departments, consumption averages up to 40 litres/bed per day [20], where hot water is required, metering and constant monitoring of consumption make it possible to take

action whatever the cause of sporadic excess (due to leaks, low-efficiency taps, etc.).

It is generally possible to improve distribution and management, and obtain the greatest possible efficiency.

"Solar water heaters (SWH) are extensively used in the residential sector (67.2% of households use solar family systems), whereas, it is limited in the service (hospitals, hotels, universities) and industry sectors. About 50% of hospitals and hotels depend on electricity and petroleum products for water heating, and those equipped with SWH can only cover 40% and 25% of their demand from hot water by solar energy in hospitals and hotels, respectively. The existing installed capacity in all sectors is totaled 1,032,000 m^2 (as shown in figure 2.4) of which 7100 m^2 in the service sector. This can produce 647 GWh per year and saves 350 MNIS yearly to the national economy. The avoided emissions of CO_2 are evaluated at 450,000 ton per year, or avoided damage 8 MNIS. The market of SWH (45 MNIS) can be doubled if proper policy with efficient financial scheme is adapted for promotion, and encouraging the use of solar collective systems, beside improvement and control of the quality. A further potential for SWH is foreseen in the service sector through extending the existing installations to cover more demand (about 60%), and also through new installations in the unequipped centers. This is estimated at about 8500 m^2, 9800 m^2, and 1000 m^2 of solar panels in hospitals, hotels and universities, respectively [21]". The most commonly used system is family system- thermosyphonic open circuit type. The solar heating is competitive with other means of heating (unit price of SWH is about 2100

NIS). In addition, the system pay-back period is less than 2 years, when compared to that of electric systems.

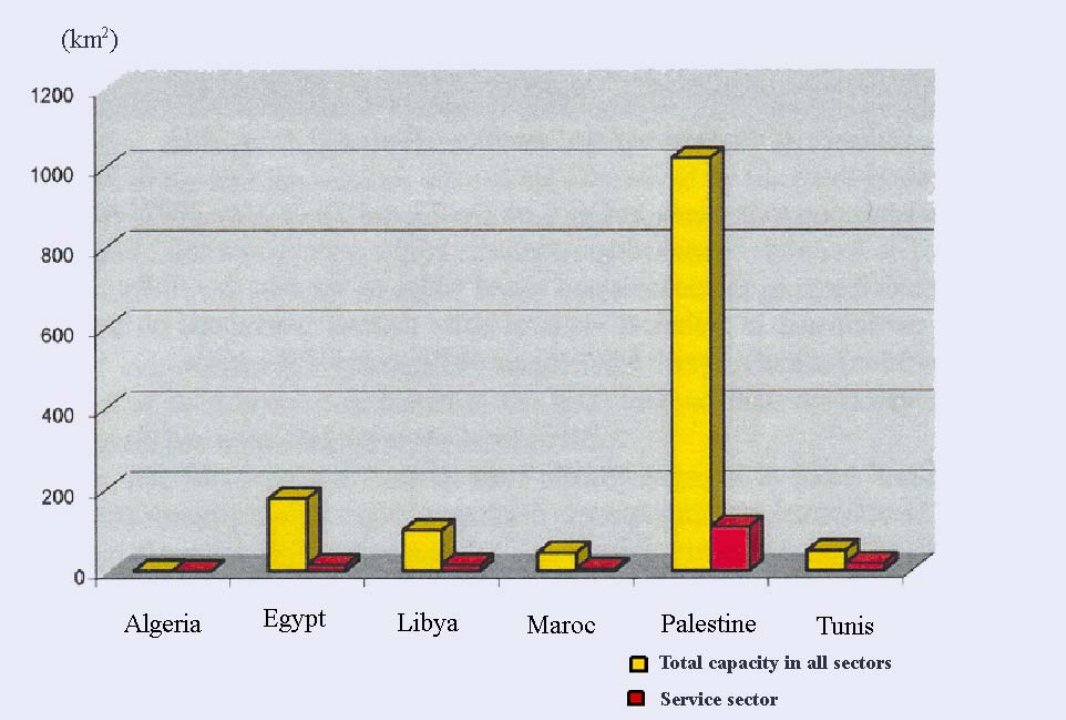


Figure (2.4): Installed Solar Collectors in the region, ASTEMB project, 2002

The use of collective systems is very limited and has to be introduced in an efficient way. The hospitals of solar water heaters in Palestine are small and simple, and need to be developed and structured.

A solar domestic hot water (SDHW) system consists of solar collectors, storage tanks, pipes, pumps, valves. It absorbs solar radiation in collectors, delivers the collected energy to the thermal storage tank, and then provides hot water for domestic usage.

Excess thermal energy is stored in one of thermal storage tanks. Figure 2.5 shows a schematic diagram of typical solar water heaters installed in Palestine of one-tank forced circulation SDHW system [21].

Figure (2.5): Schematic of a typical solar domestic hot water system [22]

Whatever heating method is employed, the temperature of the water must be maintained at or above a sufficient level to ensure adequate hygiene and disease control (approximately 55 ºC) [21].

2.4 Survey of the Previous Results of Implementation E.M.O & R.E.S in Palestine

Globally, the previous studies about Energy Conservation Opportunities (ECO's) and R.E.S were conducted abroad and they focused on the ways of energy conservation opportunities and energy consumption.

Many cases are annually implemented in different hospitals in the world. It is proved that a reduction in energy consumption by as much as 10-20 % is a realizable goal [23]. Large, long-term studies are now going on to find the reduction in energy consumption to reduce the cost.

In Jordan, a Jordanian-German Rational Use of Energy Project was made in September 2001, on the Arab Center for Heart and Special Surgery revealed that the annual cost saving was 67,989 JD/yr. , the investment

required 123,102 JD and CO_2 reduction was 1048 Ton/yr. Thus the percentage of energy saving was 19% [24].

In Palestine there are no studies covering this area according to the best of my knowledge. So the main scope of my thesis is to apply energy management procedures and audit results of electrical, thermal and solar applications in hospitals' sector.

CHAPTER THREE

CHARACTERISTICS OF THE HOSPITAL SECTOR IN PALESTINE

Chapter Three
Characteristics of the Hospitals Sector in Palestine

3.1 Status of Hospitals Sector in Palestine

In Palestine, hospitals can be classified into two categories: general hospitals (Governmental hospitals): they provide basic secondary healthcare services to a local geographic area. Some of those hospitals are large enough to provide a full compliment of advanced secondary and to some extent tertiary healthcare services. The Private hospitals (Non Governmental Hospitals) provide full compliment of advanced secondary and tertiary services in one specialty domain.

Hospitals and hospital buildings consume energy in different forms and ways on a very large scale. Hospitals are organizations which are functioning 24 hours a day, all throughout the year. The high energy consumption in hospitals sector in Palestine presents an attractive challenge and significant opportunities for energy conservation and management.

The Palestinian hospitals fall under services sector. In the West Bank, there are 54 hospitals. In 2004, there were 14 general hospitals with 1,243 beds, in addition to 40 specialized hospitals with total bed capacity of 2,812 beds [25].

The distribution of hospitals in the West Bank falls in two categories: governmental and non governmental hospitals as shown in table 3.1 [10].

Table (3.1): The number of governmental and non governmental hospitals in the West Bank [10].

Indicator	1999	2003	2004
Number of governmental hospitals	14	14	14
Number of non-governmental hospitals	23	27	40
Total	37	41	54

3.2 Energy Consumption

The energy consumption statistics in hospitals are presented as overall annual consumption figures, broken down into electrical, gas and thermal energy. To facilitate comparison of energy performance, data are presented for a number of variableties: number of beds, and m^2 gross floor area.

By calculating the total energy consumption in hospitals in the West Bank in 2007, we found the consumption is **91,218,751** kWh/year; this figure represents 1% of the total energy consumption in it. Figure 3.1 illustrates the cost of total energy consumption in governmental and non-governmental hospitals in the West Bank.

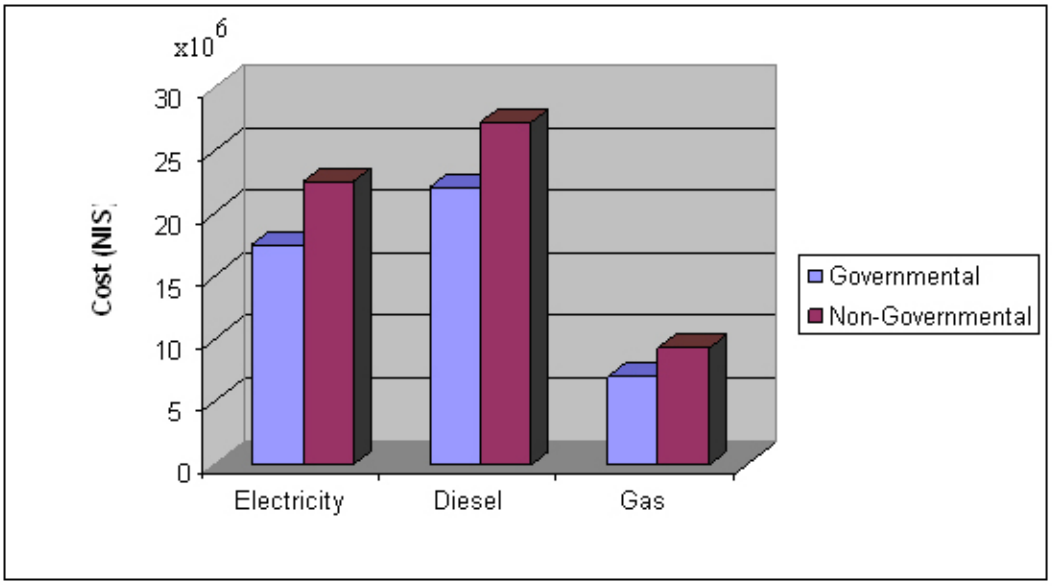


Figure (3.1): Total energy cost consum--ption of hospitals, 2007.

3.3 Hot Water Resources

In hospitals, hot water needs are continuous and significant in quantity. Where hot water is required, metering and constant monitoring of consumption makes it possible to take action whatever the cause of sporadic excess (due for example to leaks, low-efficiency taps, etc.). It is generally possible to improve distribution and management, and to obtain the greatest possible efficiency.

Solar techniques are particularly well suited to the production of hot water for hospitals, where they can be applied cost-effectively.

Whatever heating method is employed, the temperature of the water must be maintained at or above a sufficient level to ensure adequate hygiene and disease control (approximately 55°C).

3.4 Current Situation of Energy Management in Hospitals Sector

Four hospitals were selected for conducting my audit (Arab Specialty, Rafidiah, Ittihad, Watani Hospitals), and visits were carried out from March to Oct, 2007.

Direct observation and interview to administration and maintenance staff can be summarized as follows:

• There is shortage of energy management awareness, due to the lack of well-prepared and highly qualified persons.

• All hospitals are suffering from manufacturing problems of oxygen.

• Central heating systems of hospitals are almost always not functioning due to lack of maintenance.

Few medical instruments still operative (diagnostic and curative) are outdated and unreliable, and cannot work without electricity.

• Temperature inside hospitals in summer is high and living conditions are unacceptable for patients but also for healthy subjects and staff.

In fact we are now observing that:

• Some hospitals have increased up to 50% admissions, although they have cancelled all “non urgent” elective medical and surgical care.

• Hospital activities and beds are “spontaneously” gathered in selected areas of hospital buildings in order to spare energy and optimize use of equipment.

• Hospitals have plans for emergency but these plans are inappropriate to face energy shortage: most of hospitals are continuing to operate trying to maintain all services previously scheduled.

• High electricity and water bills.

Table 3.2 shows some of the hospitals name in the West Bank according to their categories.

Table (3.2): Hospitals name in the west Bank

Hospital Name	category	Energy Consumption (kWh), 2007	NO. of SWH	Type of Heating and Cooling
Rafidiah	MoH	1186511	2	Split units
Jenin	MoH	139000	2	Split units
Bethlehem Psychiatric	MoH	402670	25	Split units
Tulkarm	MoH	1312000	2	Split units
Al - Watani	MoH	544142	6	Split units
Ramallah	MoH	1528655	4	Split units
Beit Jala	MoH	816771	0	Split units
Jericho	MoH	943840	3	Split units
Salfeet	MoH	76450	0	Split units
Qalqiliah	MoH	1638	0	Split units
Hebron Hospital	MoH	1149800	0	Split units
Arab Specialty Hospital	Private	602652	0	Split units + Chiller
Al - Itihad	NGO	370221	0	Split units
Al Zaka	NGO		0	Split units
Enjeeli Hospital	NGO	280256	0	Split units
Al Razi Hospital	NGO	234200	0	Split units

CHAPTER FOUR

DESCRIPTION OF AUDITED HOSPITALS FACILITIES

Chapter Four
Description of Audited Hospitals Facilities

4.1 Introduction

To reinforce energy management, energy conservation, energy saving and reducing energy bills in hospitals sector, an auditing was done on four hospitals in Nablus city (Rafidiah, Ittihad, Arab Specialty, and Watani hospitals). I concentrated on governmental and non- governmental hospitals as a model on my auditing, covering the two kinds of hospitals in Palestine which are assigned to provide full band of medical services to Palestinian people. I did energy auditing to analyze the possibility of improving energy management and increasing the energy efficiency in the hospitals' sector.

In the first visit, factors such as energy consuming equipments, and the annual energy utilization index were taken into consideration when the interviewed organs were chosen. The interviewees were located at Arab-specialty, Rafidiah, al-Ittehad, and al-Watani hospitals, respectively.

Not only does the survey record basic data such as the amount of energy consumption (electrical & non electrical bills), type of construction, heating, and air conditioning system design, building orientation, external environmental conditions, usage behavior, unit energy consumption, and renewable resources, but it also includes general procurement information, and awareness questions. We noticed that managers in hospitals were not aware of the importance of energy management opportunities in this sector.

Many various measurement instruments were used to collect the data. The target is to recognize the potential areas for energy savings and as initial goals in energy management. Description of the auditing facilities will be separately presented throughout this chapter.

4.2 Arab-Specialty Hospital

Arab Specialty Hospital is a private sector hospital located in Nablus city; it was founded in 1997 and took effect in 2000, and had about one hundred and fifty (150) employees. The current hospital capacity is 63 beds.

The hospital has one building with a total area of approximately (2610m^2); it was built eight years ago without giving attention to insulate the building, and using solar water heaters. A detailed description of the main spaces and their distribution in floors could be seen in table 4.1.

Table (4.1): The medical units and its operating schedules in Arab Specialty hospital

Area/Zone	Area (m^2)	Working (hours / day)	
		From	To
Ground Floor	100	All the day (24 hrs)	
Administrative	360	7 AM	10 PM
Razan Center	360	7 AM	4 PM
Al-Nour Center + Operation	360	8 AM	7 PM
Administrative + Accounting + Sleeping Rooms	360	All the day (24 hrs)	
Blood Diseases unit	360	All the day (24 hrs)	
Heart diseases unit	360	All the day (24 hrs)	
External Clinic + Reception +MRI	250	8 AM	4 PM
Kitchen	100	6 AM	10 PM

The hospital contains many specialized medical centers in various domains; it mainly provides services for inhabitants of the north of the West Bank (Nablus, Jenin, Tulkarem, Salfeet, and Qalqilia).

4.2.1 Arab-Specialty hospital layout

Hospital layout illustrates the general picture of hospital main energy consuming systems or equipments and its location as shown in figure 4.1.

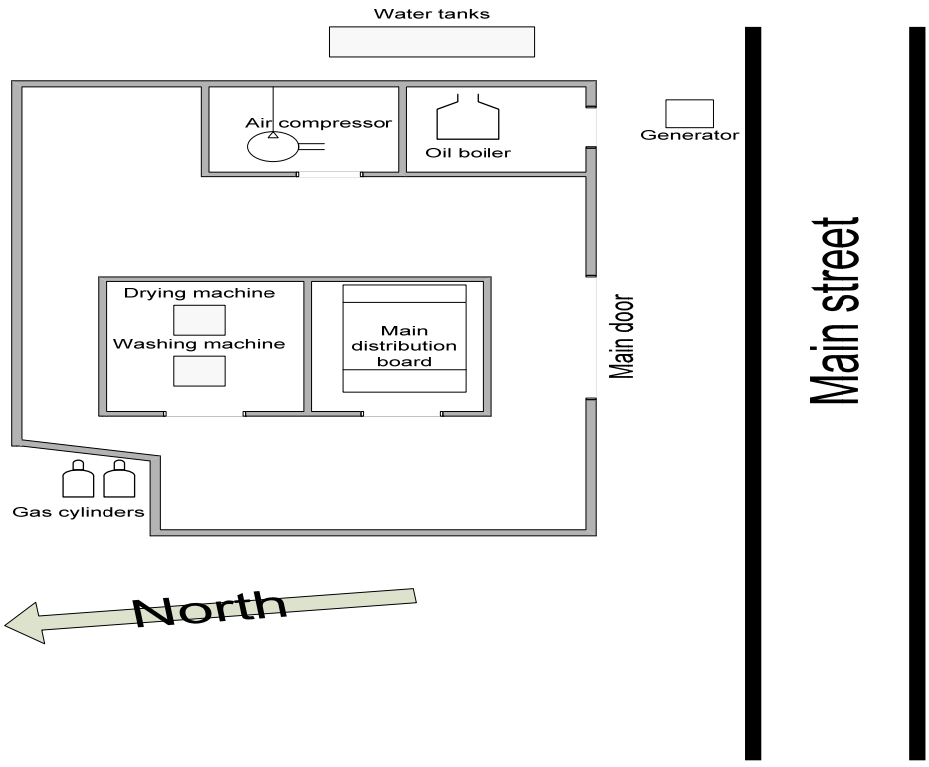


Figure (4.1): Arab-Specialty Hospital site sketch

4.2.2 Arab-Specialty hospital bill analysis

Electrical energy consumption is varied with time in months. Table 4.2 shows how the monthly total energy consumption, and also the energy utilization index (EUI) by dividing the energy consumption in kWh by the hospital internal area (2610 m^2).

Table (4.2): Electrical energy consumption and cost of Arab-Specialty Hospital, 2007.

Electrical Energy Use and Cost			
Month	**Consumption (kWh)**	**Cost (NIS)**	**EUI (kWh/m^2)**
January	33350	24345	12.77
February	26250	19162	10.05
March	34330	25060	13.15
April	42370	30930	16.23
May	25380	18527	9.72
June	68442	49962	26.22
July	70530	51486	27.02
August	90750	66247	34.77
September	77550	56611	29.71
October	42600	31098	16.32
November	50700	37011	19.42
December	40400	29492	15.47

Figure 4.2 shows electrical energy consumption in kWh and costs in (NIS) variations with respect to time in months.

Table 4.3 shows the LPG consumption distributed per month and its cost utilization index (CUI); this type of energy is used for laundry and kitchen.

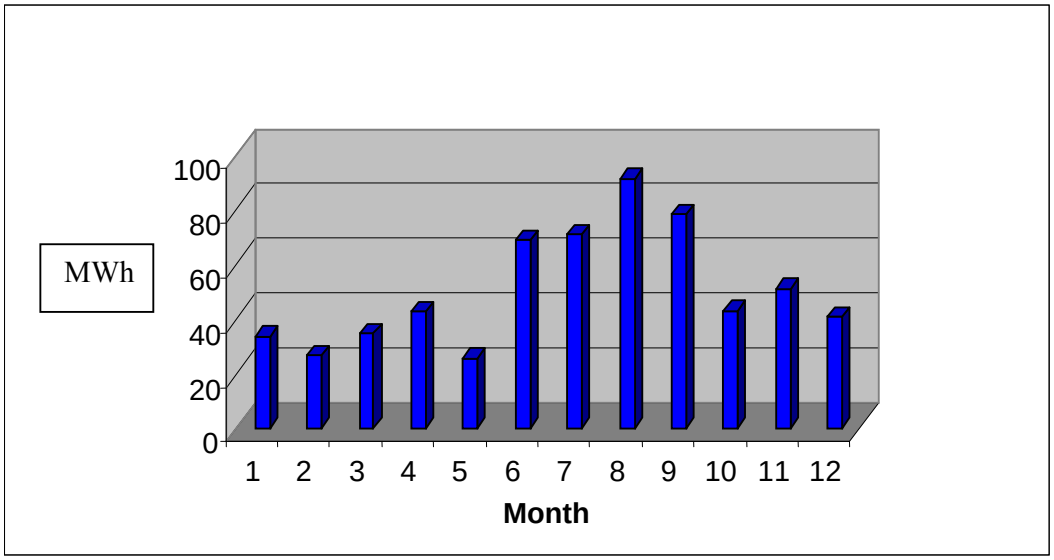


Figure (4.2): Electrical energy consumption and cost of Arab-Specialty Hospital, 2007.

Table (4.3): Liquefied petroleum gas (LPG) consumption and cost of Arab-Specialty Hospital, 2007.

Non-Electrical Energy Consumption and Cost			
Fuel Type		LPG	
Month	Consumption (kg)	Cost (NIS)	CUI (NIS/m^2)
January	310	1241	0.47
February	274	1097	0.42
March	311	1244	0.48
April	321	1284	0.49
May	176	703	0.27
June	332	1330	0.51
July	266	1064	0.41
August	304	1216	0.48
September	355	1419	0.54
October	253	1013	0.39
November	304	1216	0.48
December	350	1400	0.54

The energy consumption could be seen clearly in figure 4.3 by the chart, which shows the cost of LPG consumption/ month.

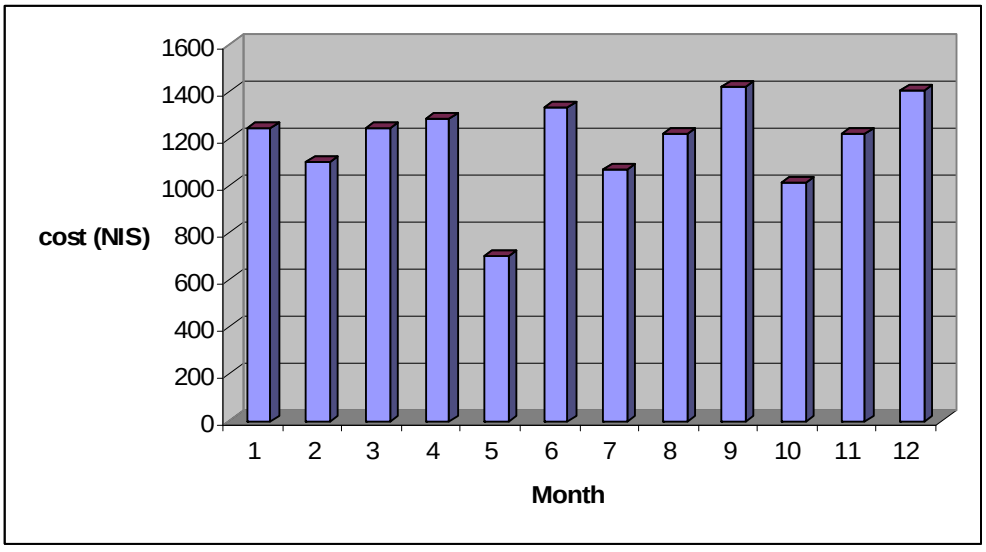


Figure (4.3): Liquefied petroleum gas consumption cost of Arab-Specialty Hospital, 2007.

Their is another type of energy consumed by the hospital which takes a considerable amount of the energy cost of diesel burned in boiler to

produce hot water utilized for daily hot water consumption all around the year, and for space heating in winter. Table 4.4 shows diesel consumption in the year of 2007.

Table (4.4): Diesel cost and consumption of Arab-Specialty Hospital, 2007.

Non-Electrical Energy consumption and Cost	
Fuel Type	Diesel
Total cost from January to September	124875 NIS
Diesel consumption	24750 liters

4.3 Rafidiah Hospital

Rafidiah hospital is an old governmental hospital located at the west part of Nablus city, which is assigned to provide full band of medical services to Palestinian people. The primary public health care facility works on an inpatient and outpatient basis, as well as emergency, surgery, and full diagnostic laboratory services. The hospital is comprised of five floors including the basement. It ranges in age from less than 10 years to over 50 years. Air conditioning is provided in administration, laboratories, surgical suites, and nurse's stations. The majority of the air conditioning is provided by mini split unit systems. Domestic hot water in the hospital is provided with an oil fired boilers. Heated water for the laundry is also provided with an oil fired boiler.

Lighting is provided with a mix of fluorescent, compact fluorescent, and a small number of incandescent fixtures. The current hospital capacity is 163 beds, with 4 to 6 in each of the patient's rooms. The hospital employs a medical, administrative and operational staff of 295 people. The total gross floor area of the buildings is 7950m^2 and the net floor height is 17.5m.

4.3.1 Rafidiah hospital layout

Rafidiah hospital layout illustrates the general of hospital main energy consuming systems or equipments, and its location is as shown in figure 4.4

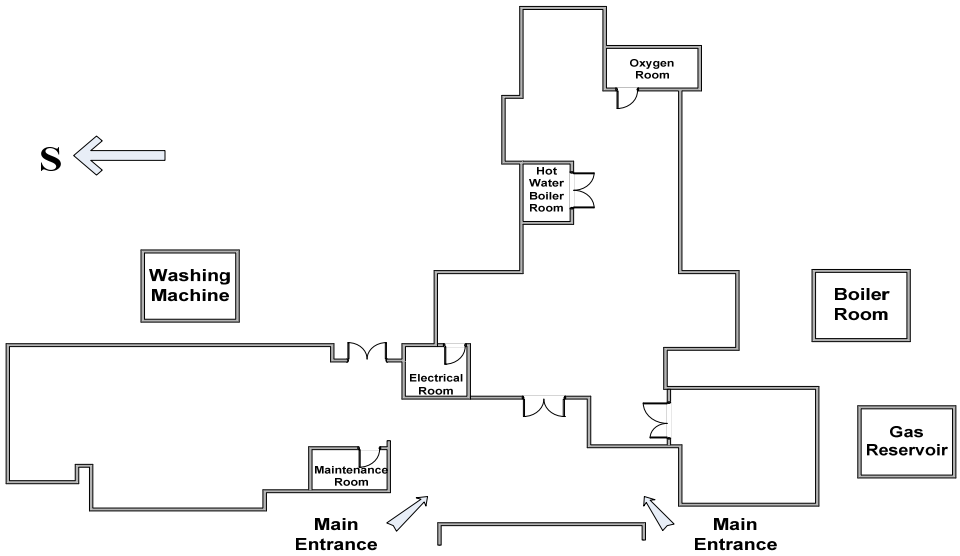


Figure (4.4): Rafidiah hospital site layout sketch

4.3.2 Rafidiah hospital electric bill analysis

The hospital electrical energy consumption averages between 44,346 and 139,682 kWh/month. There is an obvious seasonal variation in consumption. Monthly energy costs fluctuate due to the changing cost of diesel fuel on the world market. Table 4.5 shows the electrical energy consumption kWh/month, 2007.

Table (4.5): Electrical energy consumption and cost in Rafidiah hospital, 2007.

Electrical Energy Use and Cost			
Month	**Consumption (kWh)**	**Cost (NIS)**	**EUI (kWh/m^2)**
January	101202	73877	12.72
February	140980	102915	17.73
March	88630	64699	11.14
April	94568	69034	11.89
May	101808	74319	12.80
June	116082	84739	14.60
July	138358	101001	17.40
August	139682	101967	17.57
September	95191	69489	11.97
October	68012	49648	8.55
November	57642	42078	7.25
December	44346	32372	5.57

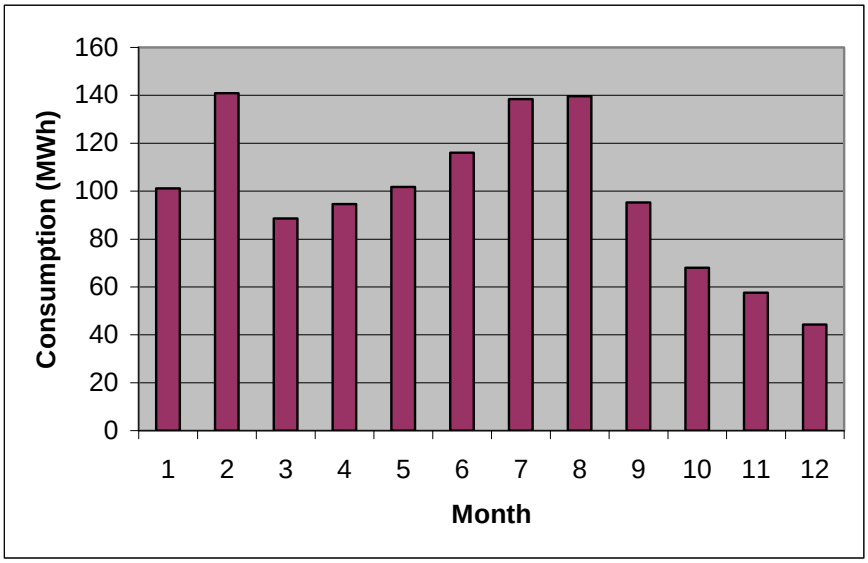


Figure (4.5): Electrical Consumption (MWh/month) in Rafidiah hospital, 2007.

It is noticeable that consumption is rising in February and August due to heating and air-conditioning systems.

Table 4.6 shows the non-electrical energy consumption and Cost (natural gas consumption distributed per month and cost) utilization index (CUI) was included. This type of energy is used for laundry and kitchen.

Table (4.6): Non-electrical energy use and cost in Rafidiah hospital, 2007.

Non-Electrical Energy Consumption and Cost			
Fuel Type		LPG	
Month	Consumption (kg)	Cost (NIS)	CUI (NIS/m^2)
January	2875	11500	1.45
February	2793	10890	1.36
March	1575	6300	0.79
April	1500	6000	0.75
May	751	3005	0.44
June	1750	7000	0.88
July	1050	4200	0.52
August	875	3500	0.44
September	725	2900	0.36
October	775	3100	0.38
November	450	1800	0.22
December	475	1900	0.23

The energy consumption could be seen clearly in figure 4.6 by chart which shows LPG cost/month.

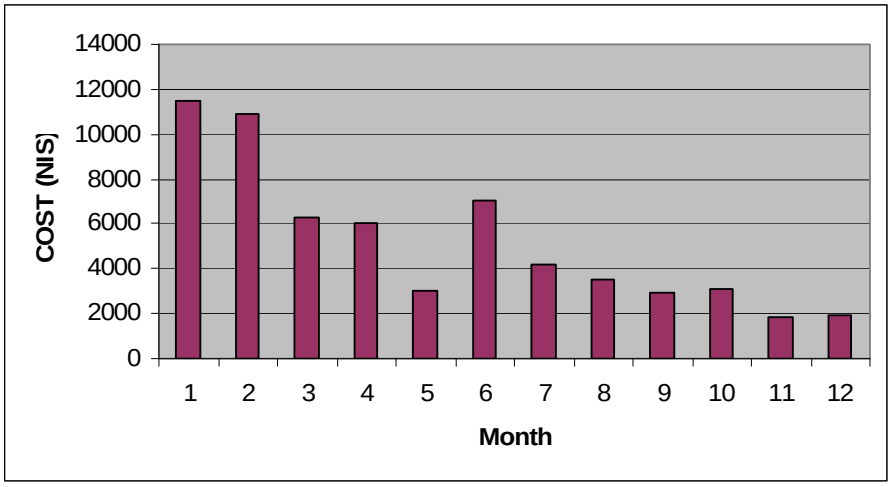


Figure (4.6): Liquefied petroleum gas monthly cost at Rafidia hospital, 2007.

4.4 Al- Ittihad Hospital

Al-Ittihad is a non governmental (NGOs) hospital owned and operated by UNRWA. The NGOs hospitals managed to extend their activities to cover many service areas. They are dominantly available in Jerusalem, and the WB.

Ittihad hospital is a series of one to four levels interconnected through long corridors and service rooms. The hospital main entrance is located at the north of Al-Ittihad street at Ebal mountain in the north of Nablus city. The whole complex capicity has approximately 75 patient beds.

The original buildings were built in 1973 as a rest home and hospital. It was known as The General Women's Union. The main type of the construction is non- isolated stone walls.

Air conditioning is provided partially to the administration, laboratories, and surgical suites. The majority of the air conditioning is provided with mini split systems, because the chillers were turned off more than five years ago. Domestic hot water in the hospital is provided with two diesel boilers.

Lighting is provided with a mix of fluorescent, compact fluorescent. The current hospital employs a medical, administrative and operational staff of 130 people. The total gross floor area of the buildings is 4450 m^2 and the net floor height is 13 m.

4.4.1 Ittihad hospital layout

Ittihad hospital layout shows us the general hospital main energy consuming systems or, equipments, and its location is as shown in figure 4.7.

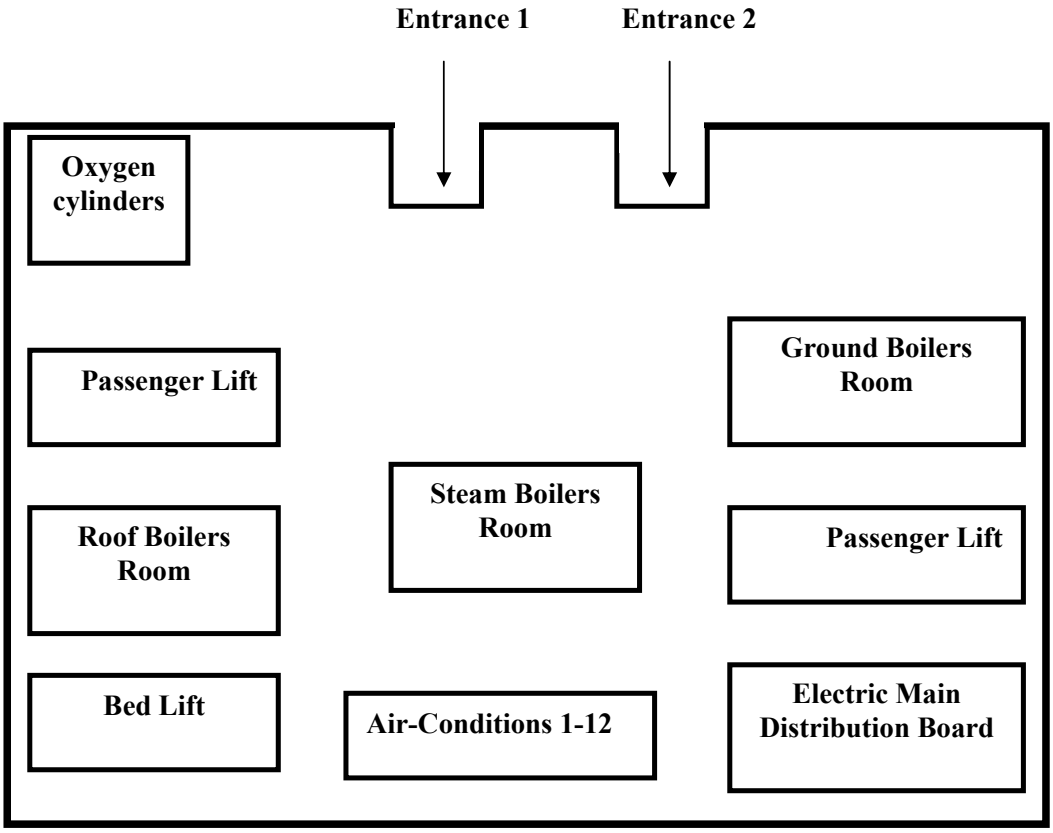


Figure (4.7): Ittihad hospital layout site sketch

4.4.2 Electric bill analysis

The monthly electrical energy consumption in the hospital varies between 6668-3610 kWh/year. There is an obvious seasonal variation in consumption. Energy costs fluctuate due to the changing cost of diesel fuel on the world market. Figure 4.8 shows the electrical energy consumption kWh/month, 2007.

Table (4.7): Electrical energy consumption and its cost of Ittihad hospital, 2007

Electrical Energy Use and Cost			
Month	**Consumption (kWh)**	**Cost (NIS)**	**EUI (kWh/m^2)**
January	37097	27080	8.34
February	35000	25550	7.87
March	43000	31390	9.66
April	32089	23424	7.21
May	42580	31083	9.57
June	45473	33195	10.22
July	38671	28229	8.69
August	42520	31039	9.56
September	33890	24739	7.62
October	35265	25743	7.92
November	32001	23360	7.19
December	27582	20134	6.20

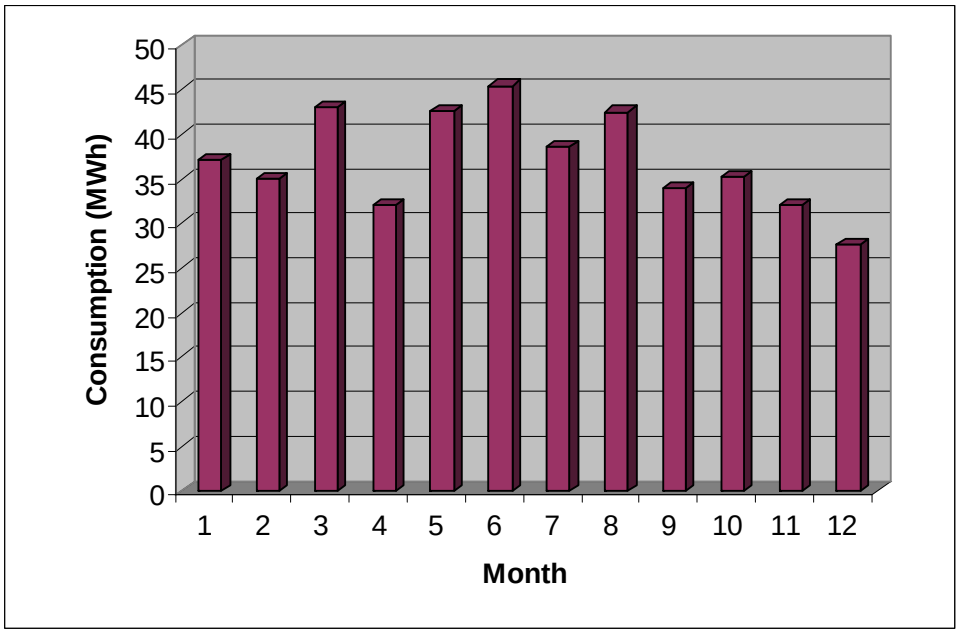


Figure (4.8): Electrical consumption kWh/month, 2007 of Ittihad hospital

The diesel energy fluctuates yearly due to the diesel consumption in winter for heating and hot water. Figure 4.9 shows diesel monthly consumption.

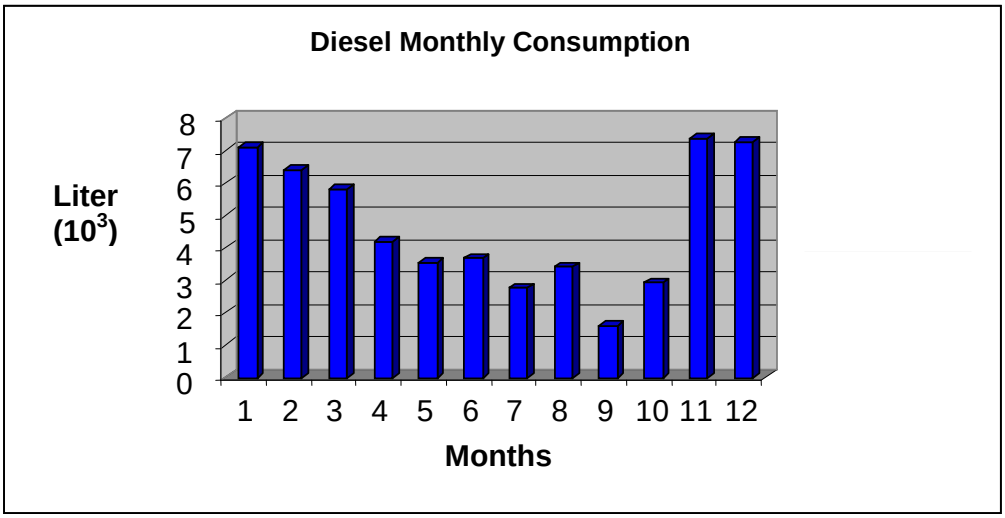


Figure (4.9): Diesel monthly consumption of Ittihad hospital, 2007

The consumption of non electrical energy and its cost per month is shown in table 4.8.

Table (4.8): Ittihad hospital diesel consumption and cost per month, 2007.

Non-Electrical Energy consumption and Cost		
Fuel Type	**Diesel**	
Month	**Consumption (liter)**	**Cost (NIS)**
January	7100	35500
February	6400	32000
March	5800	29000
April	4188	20940
May	3529	17645
June	3685	18425
July	2761	13805
August	3415	17075
September	1615	8075
October	2928	14640
November	7382	36910
December	7250	36250

4.5 Watani Hospital

Al-Watani hospital is an old governmental hospital located at the middle of Nablus city. The primary public health care facility provides on an inpatient and outpatient basis, as well as emergency, surgery, and full diagnostic laboratory services. The hospital is comprised of a number of two floors. It ranges in age from less than 10 years to over 40 years. Air conditioning is provided in administration, laboratories, surgical suites, nurse's stations. The majority of the air conditioning is provided with mini split systems. Domestic hot water in the hospital is furnished with diesel boilers and some solar water heaters unit.

Lighting is provided with a mix of fluorescent, and compact fluorescent. The current hospital capacity is 119 beds, with 4 to 6 in each patient's room. The hospital employs a medical, administrative and operational staff of 234 people. The total gross floor area of the buildings is 3000 m^2.

4.5.1 Watani hospital layout

Watani hospital layout illustrates the general picture of hospital main energy consuming systems or equipments, and its location is as shown in figure 4.10

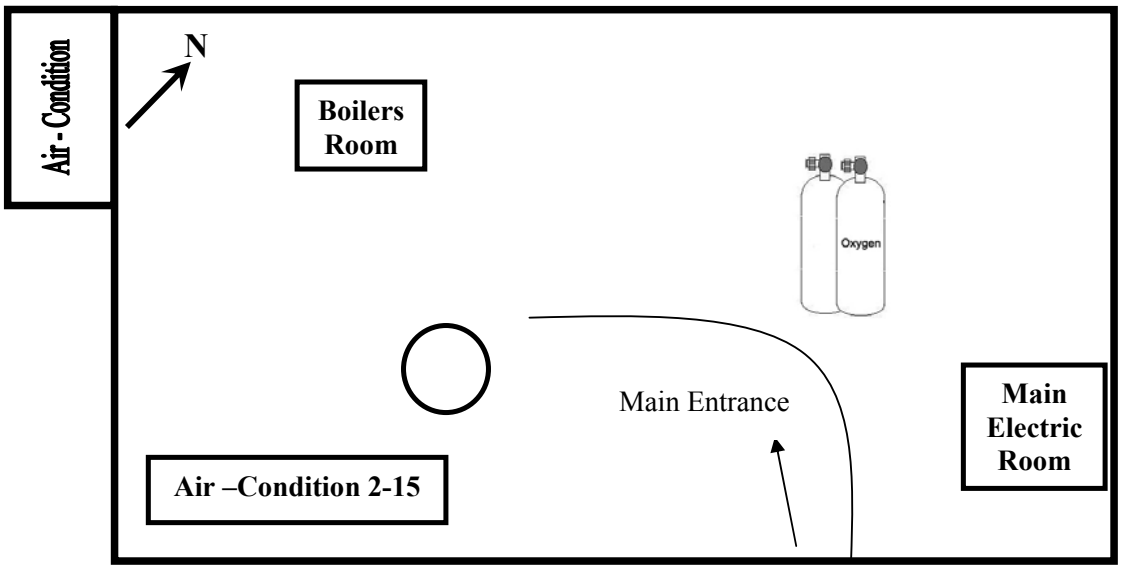


Figure (4.10): Watani hospital layout site sketch

4.5.2 Watani electric bill analysis

The monthly average electrical energy consumption in the hospital is 544142 kWh/year. There is an obvious seasonal variation in consumption. Table 4.8 shows the electrical consumption of Al-Watani hospital per month-2007, likewise Figure 4.11 shows the electrical energy consumption kWh/month, 2007 by chart.

Table (4.9): Al - Watani electrical energy consumption, 2007

Electrical Energy Consumption and Cost			
Month	**Consumption (kWh)**	**Cost (NIS)**	**EUI(kWh/m^2)**
January	81237	59303	27.07
February	42983	31377	14.32
March	34750	25367	11.58
April	68172	49765	22.72
May	52138	38060	17.37
June	43257	31577	14.41
July	54972	40129	18.32
August	51658	37710	17.21
September	32632	23821	10.87
October	34667	25306	11.55
November	27280	19914	9.09
December	20396	14889	6.79

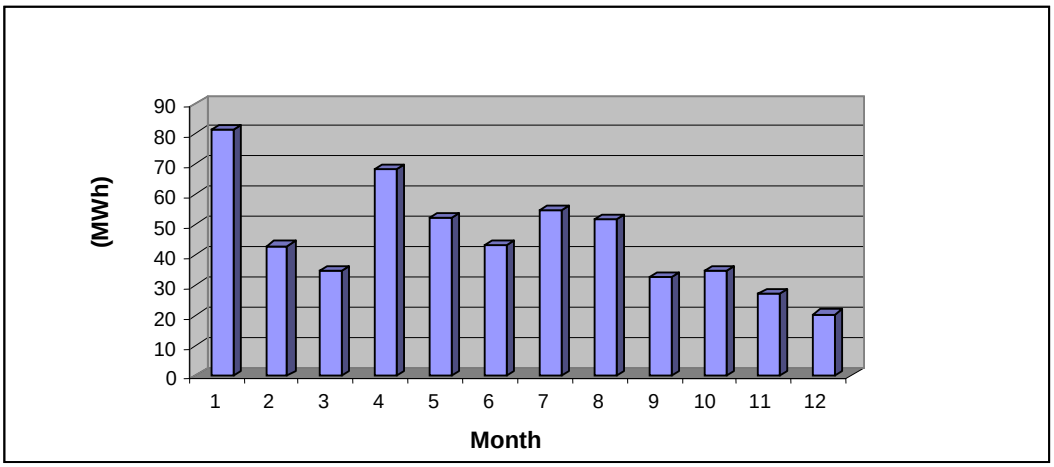


Figure (4.11): Al -Watani electrical consumption kWh/month, 2007

It is noted that the consumption is rising in January, April and July due to heating, air-conditioning system, and this can be seen in EUI column.

Table 4.10 shows the diesel consumption and cost per month for Al-Watani hospital.

Table (4.10): Al - Watani non-electrical energy consumption

Non-Electrical Energy Use and Cost		
Fuel Type	**Diesel**	
Month	**Consumption (kg)**	**Cost (NIS)**
January	7500	37500
February	6500	32500
March	3500	17500
April	3500	17500
May	4300	21500
June	-	-
July	-	-
August	-	-
September	1000	5000
October	-	-
November	5000	25000
December	4000	20000

Diesel monthly energy consumption could be seen clearly in figure 4.12.

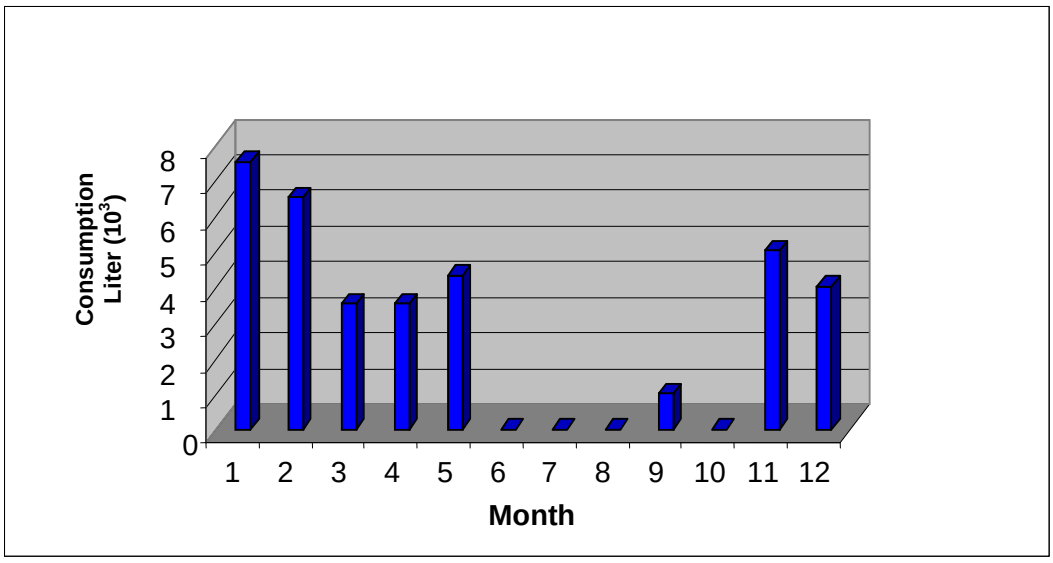


Figure (4.12): Al -Watani diesel monthly consumption, 2007

CHAPTER FIVE

ENERGY AUDIT IN DEFINITE HOSPITALS

Chapter Five
Energy Audit in Definite Hospitals Sector

The energy conservation opportunities (ECO) will be focused on boilers system, lighting, power factor improvement, air-conditioning, oxygen generation unit and solar water heaters. Every ECO will be analyzed and presented separately.

5.1 Energy Management in Arab-Specialty Hospital

5.1.1 Improving boiler system operation

The hospital contains three boiler units: one of them is of smaller capacity (250kW) than others, and the two larger boilers are similar in capacity (450 kW); these two boilers' units are used for space heating in winter season, and the lower capacity boiler is used for supplying hot water demand by patients and employees.

Adjusting boiler Air – Fuel Ratio

One of the two larger boilers could cover the hospital demand for space heating and the other standby.

The apparatus used to measure the boilers combustion efficiency is "Combustion Analyzer". The boiler efficiency at excess air equaling 24.4% was **82.0%**, then after controlling the excess air and minimizes it to 11%, the boiler combustion efficiency improved to reach **83.2%.**

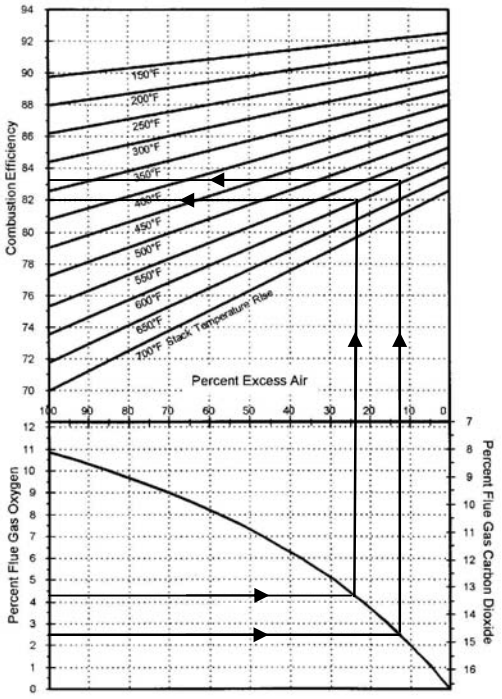


Figure (5.1): Combustion efficiency chart for number 6 fuel oil

This adjustment is to improve the combustion efficiency of the boiler. Referring to the combustion analyzer data measured shown in table 5.1, the percentage of O_2 was 4.4 % and the stack temperature is around 589 ºF.

The case illustrates that the air- to- fuel ratio (Excess air level) is different for different boilers load, and improve the combustion efficiency; we must reduce the excess air. Table (5.1) shows the boiler flue gas data measured by the combustion flue gas analyzer.

Table (5.1): Arab-Specialty Hospital boiler flue gas data

Boiler flue gas data for small capacity boiler	
Temperature (^oF)	589
O_2%	4.4
CO_2%	14.4
CO%	10.19
Excess air %	24
Losses%	10.8
NO_x (ppm)	57
SO_x (ppm)	44
Efficiency %	82

The annual fuel savings can be realized by increasing the combustion efficiency to 83.2%, and this figure can be estimated also from the equation 5.1.

$$Fuel\ \text{saving} = U \times \left[1 - \frac{\eta_{before}}{\eta_{after}}\right] \quad [17] \ldots\ldots\ldots\ldots\ldots\ldots 5.1$$

Where:

U: annual fuel usage by boiler, NIS/yr

η_{before}: combustion efficiency before improvement

η_{after} : combustion efficiency after improvement

So using equation 5.1 to compute the saving, we obtain:

Saving = U × (1 – (0.9856)

= U × (0.0144)

= 40000 × (0.0144)

= 576 (NIS/year).

So that the saving achieved of diesel fuel in liters could be calculated, by dividing the quantity saved by 5 NIS / liter.

Diesel saving in liters = 576 / 5

= 115.2 liters /year

Knowing that each liter of diesel gives 10.5 kWh of energy, we can compute the saving in kWh/year.

Saving in kWh/year = 115.2 Liter × 10.5 (kWh/Liter)

= 1209.6 (kWh/year)

Applying the previous algorithm to other hospitals resulted in the following table 5.2

Table (5.2): Summary of the resultant saving in boilers system

Hospital Name	Energy Saving (kWh/year)	Cost Saving (NIS/year)
Arab-Specialty Hospital	1210	576
Rafidiah Hospital	31395	22918
Watani Hospital	18900	13797
Ittihad Hospital	9935	7253

5.1.2 Solar panels saving opportunity

It was noticed in the diagnostic phase that there was no solar water heater in the hospital in order to utilize the energy of the sun radiation in water heating, so that an economical analysis was done to check the feasibility of installing solar water heater on the hospital roof. Table 5.3 shows data used in the economical analysis.

Table (5.3): Daily hot water demand of Arab-Specialty Hospital

Category of consumption	Hot water consumption (liter / day)	Total (liter / day)
63 patient beds	40	2520
10 showers	20	200
40 lavatories	15	600
Total		3320

To compute the energy consumed by this 3320 liter of hot water, we assume that the average temperature of the water is 15 ^{o}C, and the solar collectors will increase it to 55 ^{o}C; then energy needed could be calculated using the following equation 5.2:

$$Q = m \times C_p \times \Delta T \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad 5.2$$

Where:

Q: heating energy needed (kj)

m: mass of hot water needed per day in liters

C_p: specific heat of water which= 4.18 kj / (kg.^{o}C).

ΔT: temperature difference between water before entering the solar panel and after it in Celsius.

So using the equation 5.2 to compute energy consumption we obtain:

$$Q = 3320L \times \frac{1kg}{1L} \times \frac{4.18kj}{kg.\circ c} \times [55-15]$$

Q = 555104 kj

We use the following factor to convert the kj into kWh.

1 kg diesel → 11000 kcal

1 liter diesel → 10.5 kWh

So the heating energy needed in kWh equals 154.19 kWh/day, the figure could be saved by installing solar panels and utilizing the solar energy.

The hospital uses diesel fuel in boilers, and each liter of diesel stores chemical energy which be converted into kWh.

1 kg diesel → 11000 kcal 1 liter diesel → 10.5 kWh 1 kj → 3600 Wh

Now we can use the following equation to measure how many liters of diesel should be burned to obtain energy needed to heat 3320 liter of water from 15^{o}C to 55^{o}C, taking into consideration boiler efficiency (over all efficiency) which approximately equals 75%.

$$\eta = \frac{P_{out}}{P_{in}} \times 100\% \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad 5.3$$

Where:

η: boiler over all efficiency (approximately = 75%).

P_{out}: energy output from the boiler

P_{in}: energy input to the boiler.

Where:

$$P_{in} = \frac{154.19}{0.75} = 205.6 kWh/day$$

P_{in} = 44202.7 (kWh/year), we assume that the annually sun shine days are 215.

And to see how many liters of diesel are needed, we divide the input power by 10.5 kWh/liter of diesel fuel; the result is 21.5 liter of diesel fuel needed per day.

Knowing that the cost of diesel is 5 NIS/liter, so the daily cost is 107.5 NIS, and then multiplying the result by 3000 hours per year, we have 23112.5 (NIS/year). Through this method, cost could be saved by using solar water heater panels.

Now after calculating the energy needed per day on the basis of kWh, the solar panels could be designed by using equation 5.4

$$\mathbf{A_{collector}} = \frac{\text{Energy Demand}}{\text{Solar Radiation} \times \eta_{collector}} \quad \text{..... 5.4}$$

Where:

$A_{collector}$: Is the area in m^2 of the collector needed to supply energy equal to the daily demand.

Energy demand: Amount of energy consumption necessary to heat the water daily.

Solar radiation: Daily solar radiation intensity in kWh / m^2.day

By using equation 5.4, we can calculate the area of collectors as follows:

$$A_{collector} = \frac{154.19}{[5.4 \times 0.35]} \quad \text{.....5.5}$$

$$= 81.85 \ m^2$$

And to see how many collectors are needed, the next formula 5.5 could be used.

$$\text{Number of collectors} = \frac{\text{Area of Collector}}{1.7\,m^2} \quad \text{.....5.6}$$

Where:

The area of one plate collector = 1.7 m^2

So that

$$\text{Number of collectors} = \frac{81.85}{1.7} = 48 \text{ Collectors}$$

The cost of solar water heaters system containing 48 collectors is 33600 NIS.

To check the feasibility of this opportunity, simple pay back period will give good estimation by using the following equation 5.7:

$$\text{SPBP} = \frac{\text{Investment}}{\text{Saving}} \quad \text{.....5.7}$$

$$\text{SPBP} = \frac{33500}{23112}$$

= 1.45 year

The central water heaters are illustrated in figure 5.2

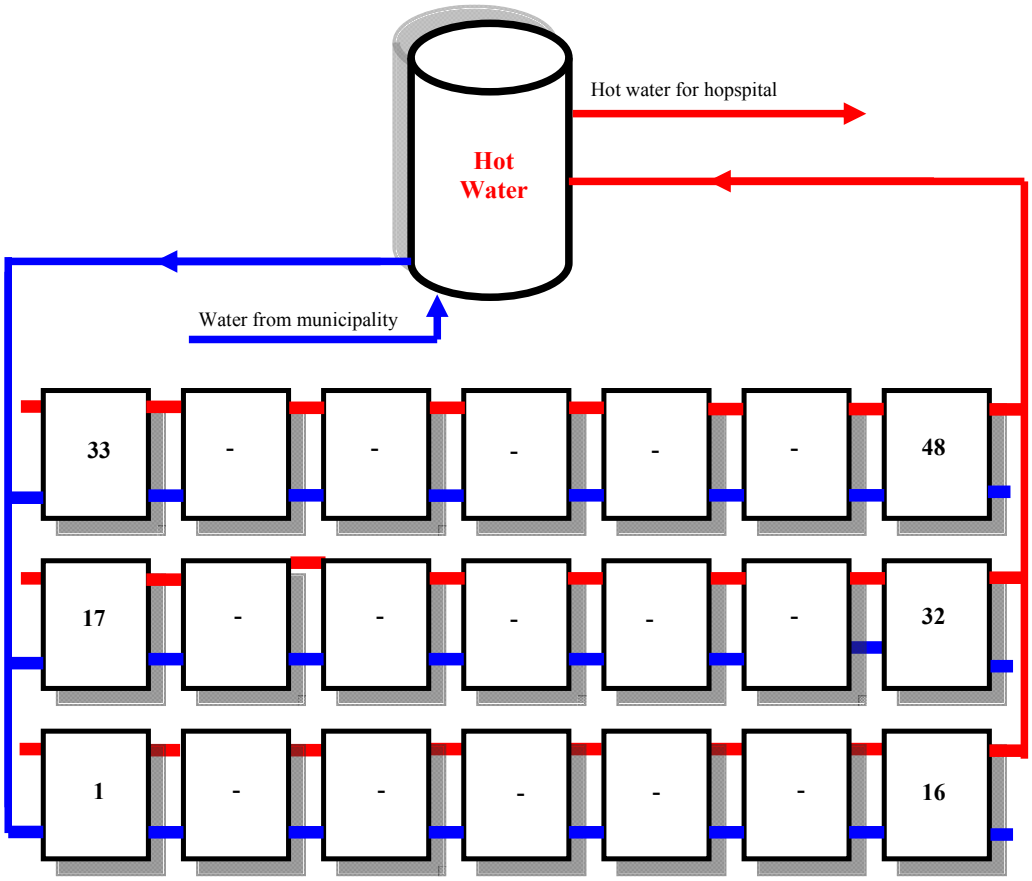


Figure (5.2): Distributions Water Heater Collectors of Arab-Specialty Hospital

Applying the algorithm scenario to other hospitals resulted in the following table 5.4.

Table (5.4): Summary of the resulted saving in solar hot water

Hospital Name	Energy Saving (kWh/year)	Cost Saving (NIS/year)
Arab-Specialty Hospital	44202	23112
Rafidiah Hospital	121831	58015
Watani Hospital	89999	42856
Ittihad Hospital	63940	33969

5.1.3 Air-Conditioning

The space cooling system in the hospital works by electrical energy; it covers about half of the total volume. The energy consumption in the

system could be estimated by calculating the difference of energy average consumption from winter to summer. The average electrical energy consumption in winter season (without operating cooling system) could be taken as the average of consumption from January to May as follows:

Average winter month consumption = (January + February + March + April + May) / 5

= 31040 (kWh/month)

= 22659 (NIS/month)

Average summer month consumption = 71350 (kWh/month)

= 52085 (NIS/month)

Now the difference between these averages equals the space cooling consumption.

The average space cooling system consumption = 71350 – 31040

= 40310 (kWh/month).

The average space cooling system cost = 52085 – 22659

= 29426 (NIS/month).

Therefore, for calculating the consumption and cost for space cooling system per year, the average consumption and cost would be multiplied by the number of operating months (June, July, August, and September).

The annual space cooling energy consumption = 40310 × 4 = 161240 (kWh/year)

The annual space cooling cost = 161240 ×0.73 = 117705 (NIS/year)

In the diagnostic phase, it was noticed that the temperature of the chiller was set on 9^{o}C and it is too low; on the other hand the temperature of the cooled space was about 22^{o}C; this means there was a large amount of air leakage in the building because of opened windows or doors.

Saving could be achieved by increasing the temperature of the chiller. Percentage of savings was calculated as follows:

$$\text{Energy saving} = \frac{[(\text{Texisting} - \text{Tout}) - (\text{Tsuggested} - \text{Tout})]}{(\text{Texisting} - \text{Tout})} \quad \ldots\ldots 5.7$$

Where:

$T_{existing}$: the temperature inside the room (22 ^{o}C)

T_{out}: before cooling the space (30 ^{o}C)

$T_{suggested}$: suggested room temperature (24 ^{o}C)

Energy saving = [(22 – 30) – (24 – 30)] / (22 – 30)

= 0.25 = 25%

Energy consumption saving = 0.25 ×161240 = 40310 (kWh/year)

Cost reduction = 0.25 × 117705.2 = 29426 (NIS/year)

The energy saving opportunity is very attractive because it could be done without any initial investment cost and the SPBP is immediate. The figure mentioned above saves 4354 kg CO_2.

Applying the previous algorithm to other hospitals resultant in table 5.5.

Table (5.5): Summary of the resulted saving in cooling system

Hospital Name	Energy Saving (kWh/Year)	Cost Saving (NIS/Year)
Arab-Specialty Hospital	40310	29427
Rafidiah Hospital	16626	12137
Watani Hospital	21600	15768
Ittihad Hospital	6120	4468

5.1.4 Lighting system

Lighting system luminance was measured by using Lux meter data logger; the data obtained was summarized in appendix 1 and some of the lighting distributions are illustrated in table 5.6.

Table (5.6): Lighting measurements of Arab-Specialty Hospital

Building area	No. of fixtures	No. of lamps /fixture	Type of lamp/ wattage	Description	Measured	Standard
Pharmacy	8	4	Fluorescent 18W	10 lamps off	450	300
Lobby	14	4	Fluorescent 18W	13 lamps off	290	150
Corridor	7	4	Fluorescent 18W	20 lamps off	500	150
Corridor	7	4	Fluorescent 18W		300	
Corridor	7	4	Fluorescent 18W		250	
W.C	1	1	Spot 13 W			150
Microbiology lab	4	4	Fluorescent 18W	--------	600	600
Laboratory	17	4	Fluorescent 18W	4 lamps off	750	500

Building area	No. of fixtures	No. of lamps/ fixture	Type of lamp/ wattage	Description	Measured	Standard
Waiting room	17	4	Fluorescent 18W	18 lamps off and bad installation for the switches	250	200
Employee room	5 +1		Fluorescent 18W +1 emergency light 8W	18 lamps off	600	300
Manager room			Fluorescent 18W +1 emergency light 8W	4 lamps off	560	400
Corridor			Ceiling unit	1 lamp off	300	150
Corridor	17	4	Fluorescent 18W	15 lamps off	330	150
Corridor	17	4	Fluorescent 18W	--------	410	150
Patient room	4	4	Fluorescent 18W	2 lamps off (there is 10 patient rooms)	270	200
Patient room W.C	Ceiling unit	1	1	--------	220	150
Nursing room	2	4	Fluorescent 18W	3 lamps off	350	300
Headquarter nursing office	13	4	Fluorescent 18W	--------	350	350
Corridor				--------	180	150
Corridor	19	4	Fluorescent 18W +6 emergency light 8W	Remove one line of fixtures	260	150
Corridors and waiting areas	17	4	Fluorescent 18W	There is three emergency lamps 8W for each	200	150
Heart clinic	6	4	Fluorescent 18W		210	200

After applying the lamp removal technique, in Arab-Specialty hospital depending on the lumen method and according to appendix 1, the

total energy saving is 21922.5 kWh/year which equals to 16,003 NIS. The figure saves 23676.3 kg of CO_2 (1kWh equal 1.08 kg CO_2).

Applying the previous algorithm to the other hospitals leads to the following consequences shown in table 5.7

Table (5.7): Saving results in lighting system

Hospital Name	Energy Saving (kWh/year)	Cost Saving (NIS/year)
Arab-Specialty Hospital	21922.5	16003
Rafedia Hospital	35000	25550
Watani Hospital	7315	5334
Etihad Hospital	34056	24860

5.1.6 Energy conservation in oxygen generation unit

Arab Specialty hospital does not have oxygen generation unit; they buy from local market. We recommend them to buy a unit which will cover all oxygen requirements. By installing the unit, they will not buy the oxygen from the market on 650 NIS for the 132000 liter (oxygen thermos); we can obtain it from the new unit by operating time of 7.5 hours daily, which consumes 292.5 kWh. Table 5.8 illustrates the specifications of the unit and its capacity.

Table (5.8): Oxygen system saving of Arab Specialty Hospital

Type	ATALAS COPCO
Consumption	292.5 kWh
Oxygen Required	132000 L/day (1 Thermos)
Analysis	
Consumption	292.5kWh/1 thermos
Operating cost	213.52 (NIS)/day
Cost form Haddad Co.	650 NIS
Saving	436.48 NIS/day (**159,315.2** NIS/year)
Maintenance	23016 NIS/year
Initial Cost (from doners)	350,000 NIS
S.P.B.P	Immediately (2.19 year)

The unit and its maintenance cost is 350000 NIS; we will save 159315 NIS by generating the oxygen from the new unit, so the simple payback period equals to 350000/159315.2=2.19 year.

Applying the previous algorithm to other hospitals resulted in the following table 5.9

Table (5.9): Saving results in oxygen generation system

Hospital Name	Energy Saving (kWh/Year)	Cost Saving (NIS/Year)
Arab-Specialty Hospital	218240	159315
Rafidiah Hospital	239350	174726
Watani Hospital	218240	159315
Ittihad Hospital	218240	159315

5.1.7 Power factor saving opportunities

The saving opportunity is summarized by installing capacitors bank parallel to the loads to correct the phase angle between the voltage and the current so as to raise the power factor to 0.92. It is the acceptable value for electricity suppliers (required from the IEC) in order to avoid the low power factor penalties, which are supposed to be imposed by the municipalities soon according to table 5.10.

Table (5.10): Power factor proposed penalties in Palestine [6].

Power Factor value	Penalty
PF ≥ 0.92	None
0.92 ≥ PF ≥ 0.80	1% of the total bill for every 0.01 of power factor less than 92%
0.80 ≥ PF ≥ 0.70	1.25% of the total bill for every 0.01 0f power factor less than 92%
PF < 0.70	1.5% of the total bill for every 0.01 of power factor less than 92%

Measuring the average power factor of the hospital for a sufficient period of time (24 hours) using the energy analyzer device, data was

analyzed using the top link software package; the maximum and minimum power factor measuring points during this interval were shown in figure 5.3, which illustrates the existed average power factor and average real, apparent and reactive power for 24 hours at Arab-Specialty Hospital. (Appendix 2).

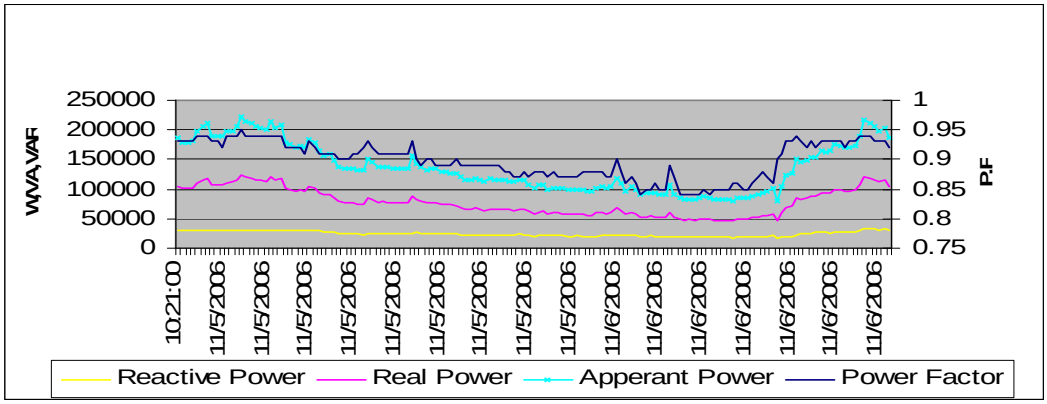


Figure (5.3): Average Power factor measured at Arab Specialty Hospital (before improvement).

To find the capacitor banks needed to improve power factor, the next equation 5.8 was used

$$Q_c = P\,(\tan\theta_1 - \tan\theta_2) \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad 5.8$$

Where:

Q_c: capacitor bank capacity needed to improve power factor in kVAR

P: maximum power kW

θ_2: $\cos^{-1}\theta_2$ (suggested power factor)

θ_1: $\cos^{-1}\theta_1$ (actual average power factor)

Now the capacitor banks needed could be calculated by using equation 5.8, the maximum power measured by energy analyzer is 93 kW.

$Q_C = 93 \times [\tan(\cos^{-1} 0.89) - \tan(\cos^{-1} 0.92)]$

$= 93 \times (0.51 - 0.42)$

$= 8.37$ kVAR

The initial investment of capacitor banks calculated by knowing each one kVAR cost 150 NIS including its control.

The total initial investment cost = 8 × 150 = 1200 NIS

Penalties saving = 1× ($\cos\Theta_2 - \cos\Theta_1$) × total consumption

= 1% × (0.92- 0.89) × 335839

= 10,075 NIS

According to the previous results, installing capacitor bank is feasible, so the simple payback period is **0.12** years.

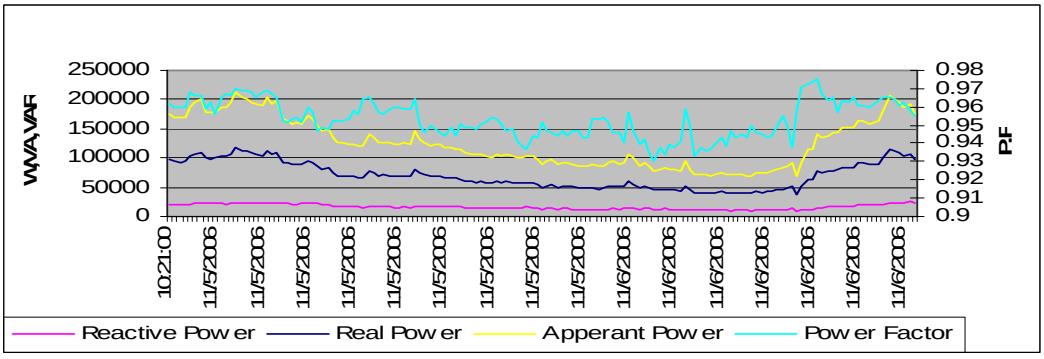


Figure (5.4): Average power factor measured at Arab Specialty Hospital (after improvement).

Applying the previous algorithm to other hospitals resulted in the following table 5.11

Table (5.11): Summary of the resulted saving in power factor correction

Hospital Name	Energy Saving (kWh/Year)	Cost Saving (NIS/Year)
Arab-Specialty Hospital	13801.6	10075
Rafedia Hospital	207637.6	151575
Watani Hospital	-	-
Etihad Hospital	-	-

5.2 Energy Saving Opportunities in studied hospitals in the West Bank - Palestine

According to the auditing facilities we summarized the saving opportunities for each hospital in details in table 5.12.

Table (5.12): Summary of the saving opportunities for hospitals auditing

Hospital Name	ECO	Saving (NIS)	Saving %
Arab-Specialty Hospital	Lighting	16003	4.76
	Cooling	29427	8.76
	Thermal	23688	18.96
	Power Factor	10075	3
	Oxygen System	159315	47.3
Watani Hospital	Lighting	22075	5.55
	Cooling	15768	3.97
	Thermal	41256	20.7
	Oxygen System	159315	40
Rafidiah Hospital	Lighting	25550	3
	Cooling	15967	2
	Thermal	72965	31
	Power Factor	151575	17
	Oxygen System	174725	20
Ittihad Hospital	Lighting	24860	7.65
	Cooling	15768	5
	Thermal	51856	18.4
	Oxygen System	159315	49

From table 5.12 above we can see that the saving percentage in lighting systems is ranged between (3 – 7.65), cooling system between (2 – 8.76), thermal system percentage is (18.4 – 31), and the saving in oxygen generation units is ranged between (20 – 49) respectivley.

Table 5.13 illustrate the total summary of the four audited hospitals

Table (5.13): Total Summary of the saving opportunities for hospitals auditing

Opportunity	Energy saved (kWh/year)	Cost reduction (NIS/year)	Opportunity implementation cost (NIS)	Equivalent kg of CO_2 reduction	S.P.B.P
Lighting System	105,108	76729	0	113,516.92	immediate
Cooling System	84,656	61,799	0	91,428.99	immediate
Thermal System	465,240	221,542	35,1145.48	502,459.27	1.585
Power Factor Improvement	221,439	161,650	14,548	239,154.42	0.09
Oxygen System	675830	493355	385383	729896.4	2.2
Total	1,552,274	1015077	751077	1,676,456	-------

Generally, the previous analysis concludes the total annual savings in the four audited hospitals is 1552274 NIS and the capacity of the conducted hospitals is 420 beds, so 54 governmental and non-governmental hospitals which have 4055 beds in the West Bank – Palestine might save 14.98 GWh.

CHAPTER SIX

SOFTWARE PROGRAMMING OF ENERGY MANAGEMENT OPPORTUNITIES

Chapter Six

Software Programming of Energy Management Opportunities

6.1 Introduction

In this chapter we'll convert the most important methods employed in energy conservation in hospitals - detailed in chapter three - into mathematical models to pave the way for methodological designs. So the subject matter could be implemented generally in studied hospitals and any establishment in the future.

Thus we indicate here that the modeling process covered all issues were formulated in the form of mathematical calculations. The remaining issues considered as suggestions and advices could be implemented through administrative procedures. We note that the modeling methods employed in the methodology convert each issue into two parts:

1. Various types of data available (nominal, measured, extracted from table, hypothetical).

2. Modeling accounts appropriate to the mathematical equations for each issue.

6.2 Flow Charts for Energy Management Opportunities

6.2.1 Methodological flow chart for calculating lighting units

Flow chart in figure 6.1 illustrates the calculation of lighting units number which passes through many steps according to a lumen method (L-shape, rectangular shape).

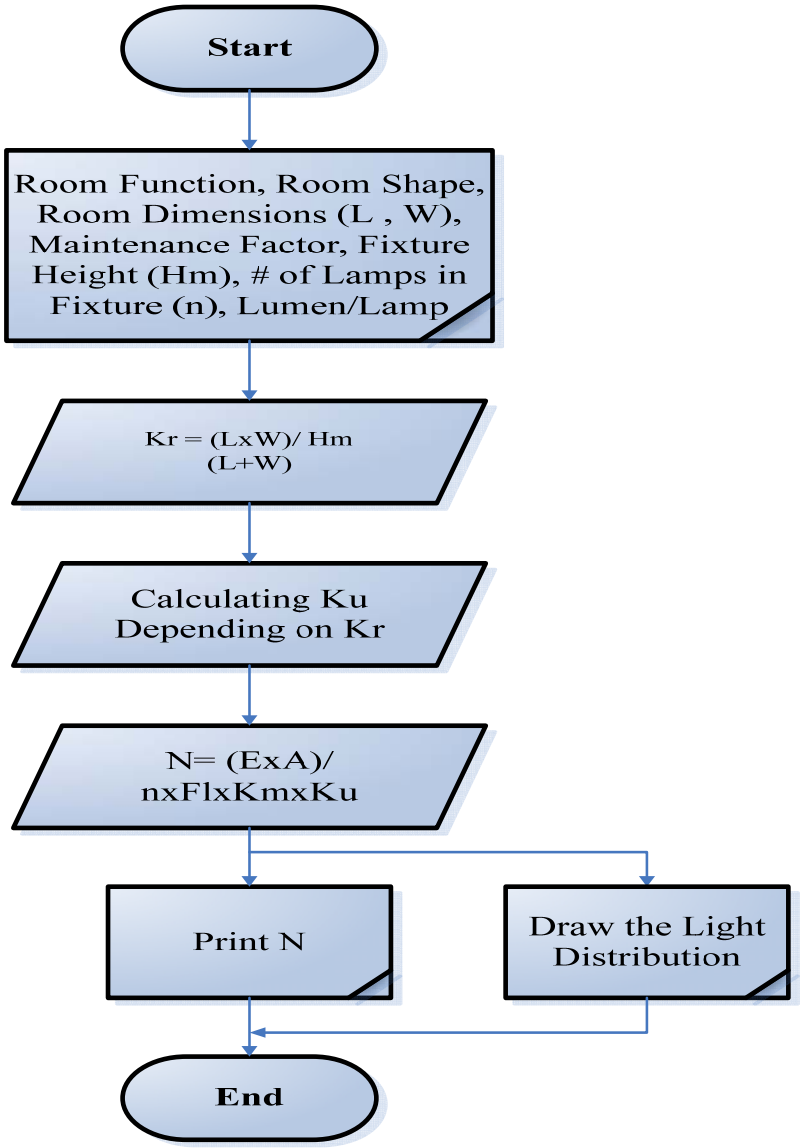


Figure (6.1): Methodological flow chart for calculating lighting units

6.2.2 Flow chart for distribution of lighting units

In distribution of electrical lighting units in hospitals, I depended on lumen method for l-shape and rectangular room shapes. Figure 6.2 shows the steps of the flow chart of this process.

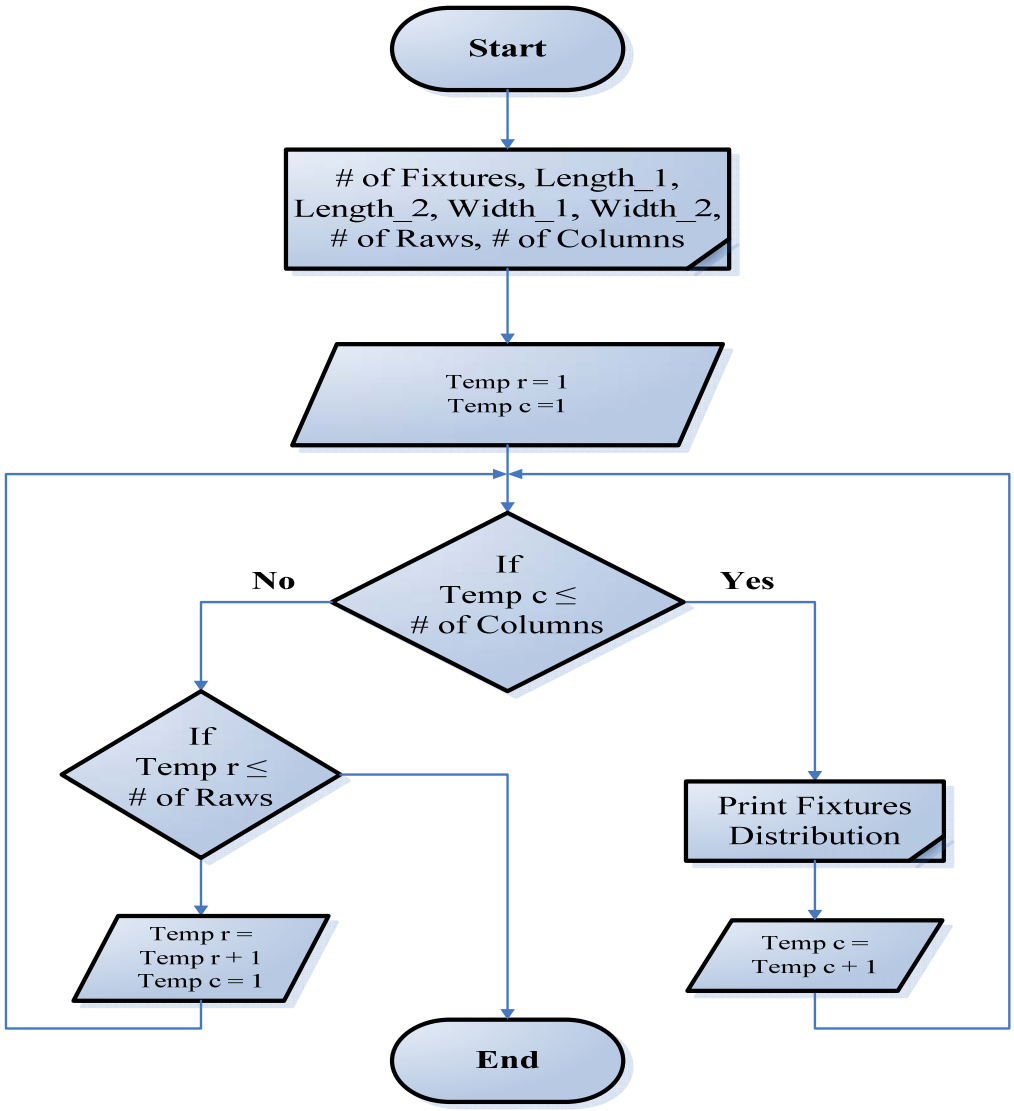
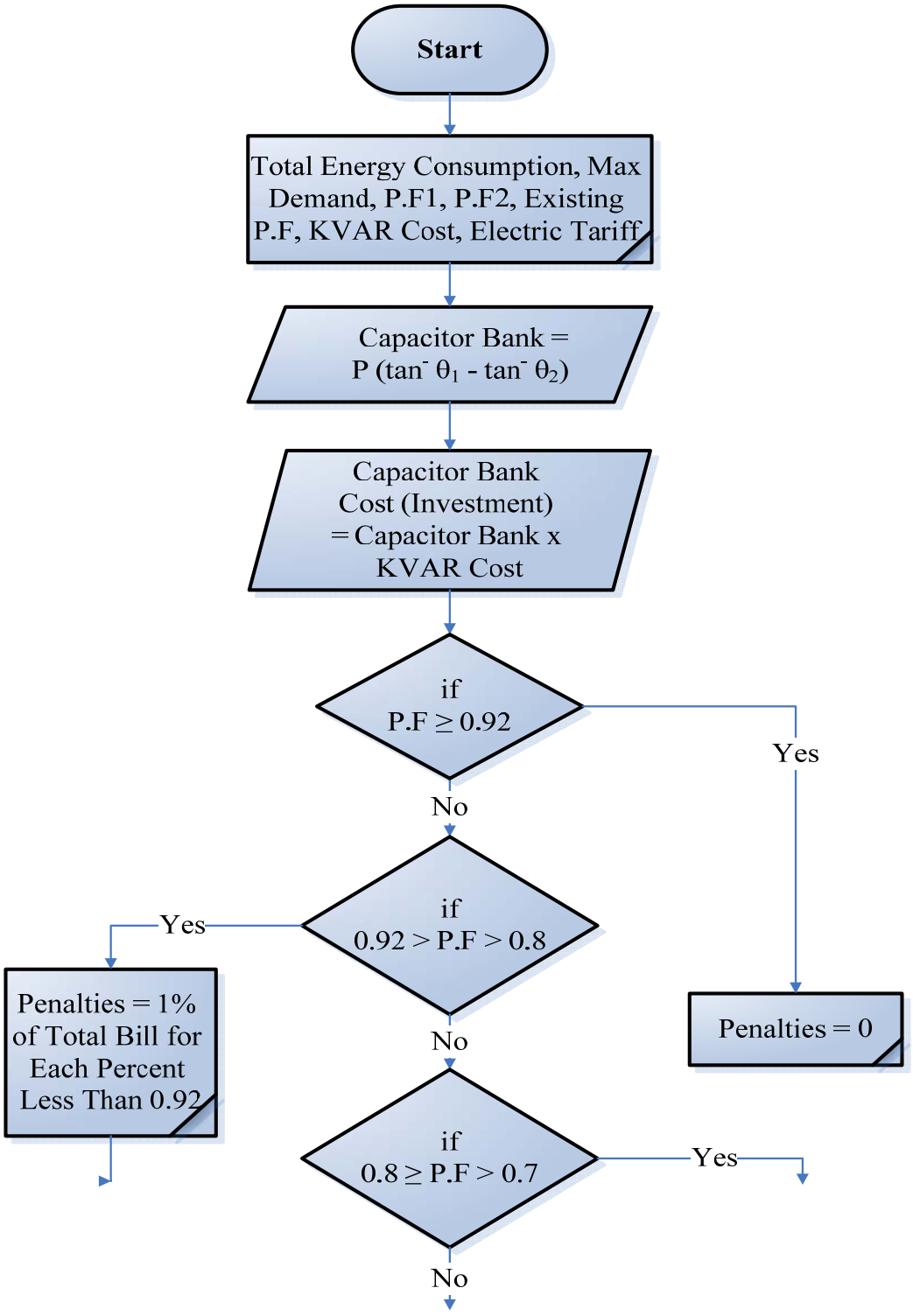


Figure (6.2): Flow chart for distribution of lighting units

6.2.3 Power factor correction flow chart

Methodological power factor correction flow chart is designed for calculating the capacitor power banks, which is necessary for compensation. The flow chart in figure 6.3 illustrates how we can calculate the penalties due to low power factor. Saving and simple payback period will be displayed at the end of the process.


Start
Total Energy Consumption, Max Demand, P.F1, P.F2, Existing P.F, KVAR Cost, Electric Tariff
Capacitor Bank = P (tan⁻ θ1 - tan⁻ θ2)
Capacitor Bank Cost (Investment) = Capacitor Bank x KVAR Cost
if P.F ≥ 0.92
Yes
No
if 0.92 > P.F > 0.8
Yes
Penalties = 1% of Total Bill for Each Percent Less Than 0.92
Penalties = 0
No
if 0.8 ≥ P.F > 0.7
Yes
No

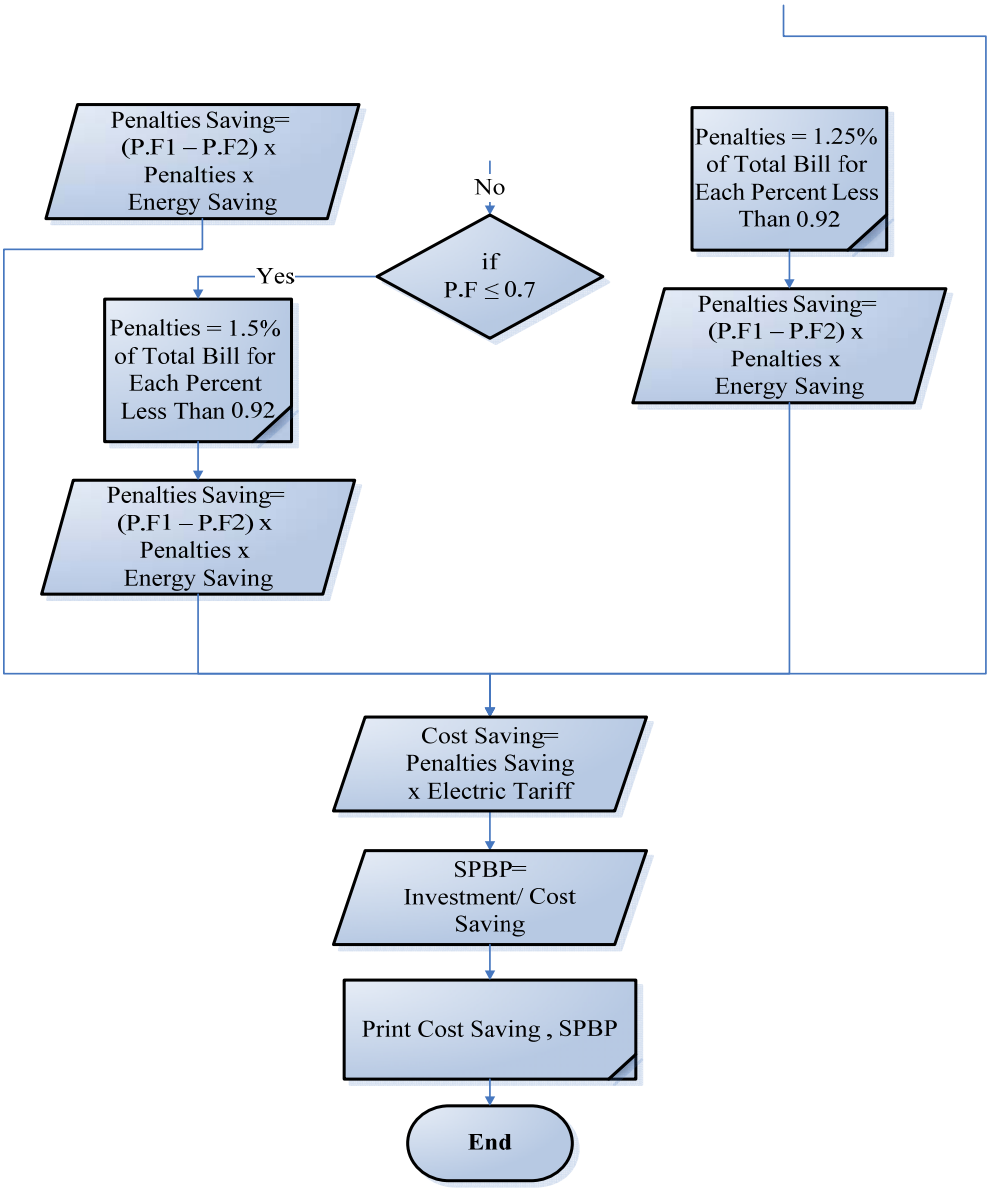


Figure (6.3): Power factor correction flow chart

6.2.4 Methodological flow chart of designing solar hot water heaters

Methodological flow chart in figure 6.4 is designed to calculate the number of the solar water heaters which are required according to the hospital hot water consumption. Many data must be entered (No. of beds, no. of showers, no. of Lavatories, no. of sunny days, efficiency of the

boiler, efficiency of the collector, T_1, T_2, C_p, solar radiation, tank price, collector price) to calculate the saving of using renewable resources to provide the hospitals with hot water.

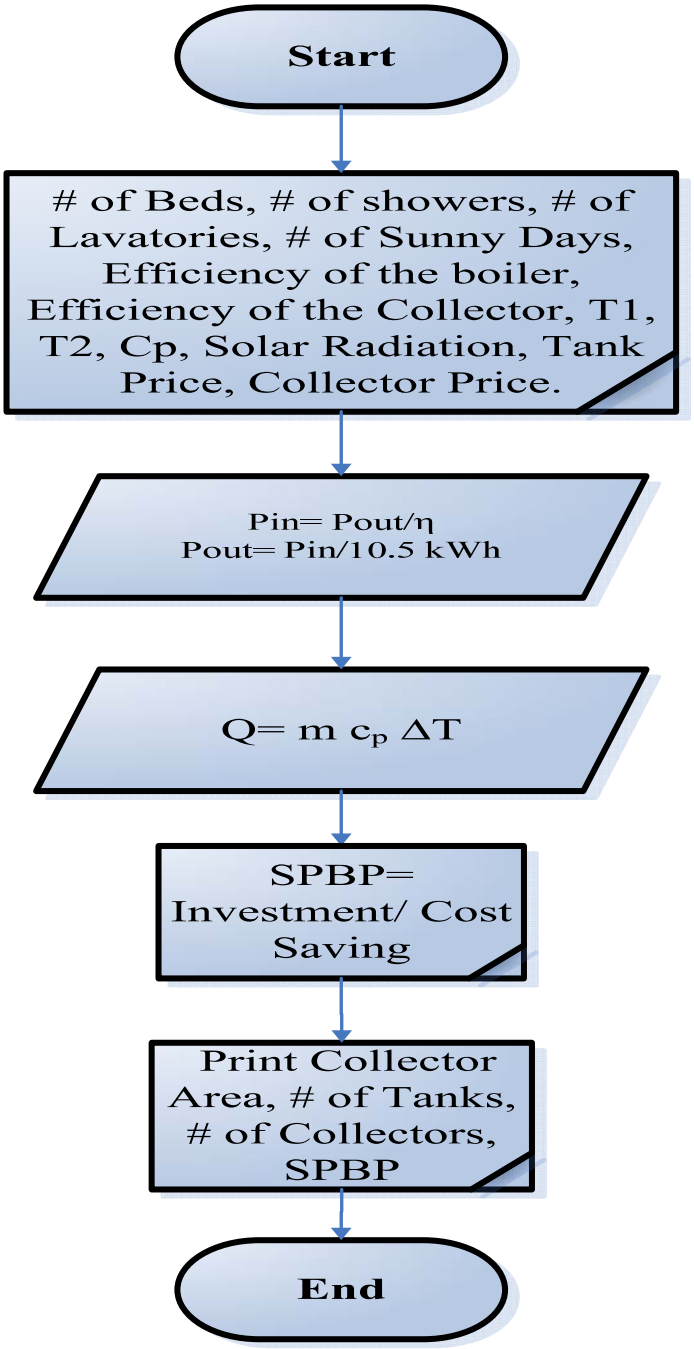


Figure (6.4): Methodological flow chart of designing solar water heaters.

6.2.5 Cooling methodological flow chart

Cooling flow chart is designed for calculating the saving of electrical consumption in air-conditioning systems according to adjustment of the thermostat temperature inside the rooms. Figure 6.5 illustrates all steps required for calculating the saving and the simple payback period.

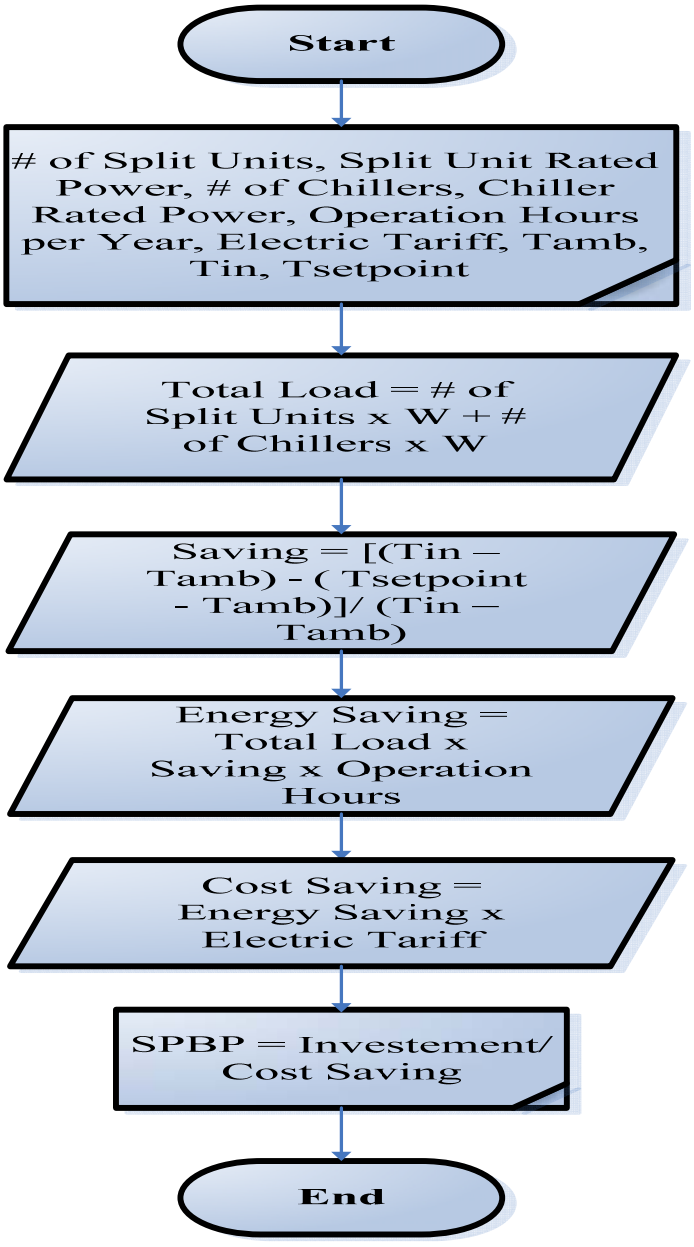


Figure (6.5): Methodological cooling flow chart

6.2.6 Heating methodological flow chart

This type of flow chart is used for increasing the efficiency in the boilers. Some data must be entered in order to calculate the saving of diesel consumption.

The idea of increasing the efficiency is represented in figure 6.6.

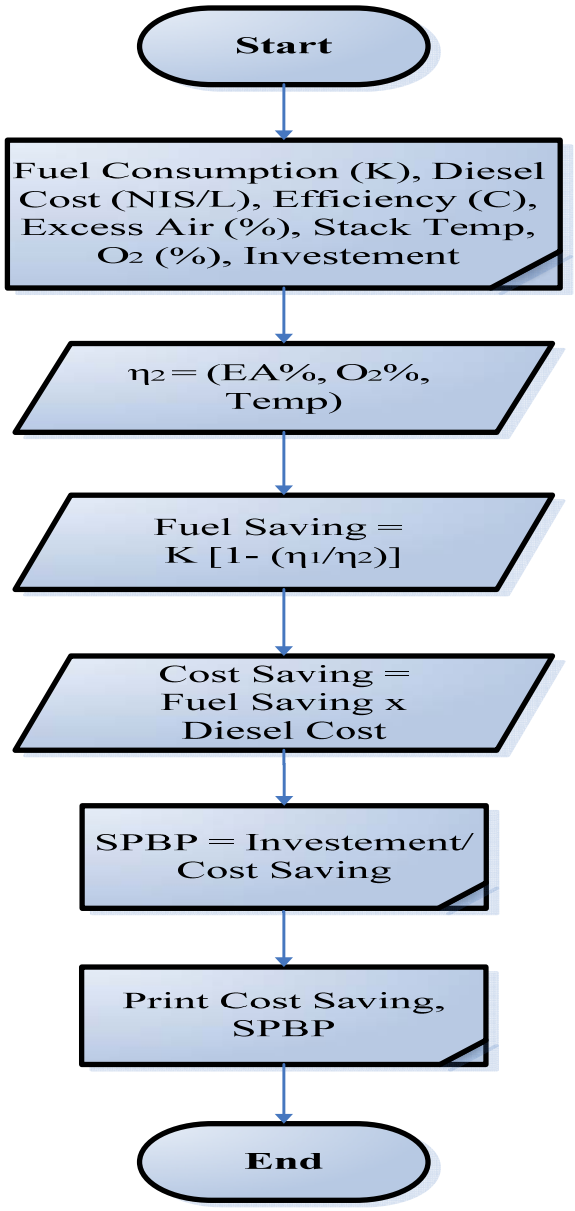


Figure (6.6): Methodological heating flow chart

6.3 Program Design

There are several opportunities to identify ways to improve the functional reality of hospitals, where studies showed that the development programme on the computer is available, and reduces the time needed to calculate the saving opportunities of lighting, air-conditioning, installation of solar water heaters, recovering the expense of capital, improving the power factor, oxygen generation unit, and raising the boilers efficiency. In designing and programming this software, we use Microsoft Excel which is one of the most powerful software, that deal with tables and mathematical equations in addition to graphic charts.

The energy conservation program, in medical foundations includes a set of partial software to certain study cases illustrated in chapter three.

The programme consists of the following steps:

- Collecting the results of field measurements using energy analyzer device such as (current, voltage, active power, reactive power, power factor).
- Collecting data from hospitals such as (the number of air-conditioning units, the number of units of existing lighting, no. of beds).
- Programming equations and processing by-vs. proposed.
- Displaying the results at the computer screen.

- Calculating the results of the implementation of proposed solutions as total annual savings, and simple payback period for each action.
- Printing the results.

6.4 Verification of the program

There are several opportunities to identify ways to improve the functional reality of hospitals, where studies show that the development programme on the computer is available, and reduce the time needed to conduct audits of the opportunities for area lighting, the installation of solar heaters, improving power factor, heating and air-conditioning systems, calculating the cost of each action and determining the recovery of investment when applying any opportunity.

Excel was adopted in assessing the energy conservation, because of its useful characteristics and easy dealing with the application of energy conservation opportunities.

6.5 How to use the program

Figure 6.7 shows the image of interface software program of the energy management opportunity in hospitals' sector. The interface illustrates six energy conservation icons in addition to the final report and the overview.

Figure (6.7): Software Programming interface.

When pressing on special lighting icon, the program moves to lighting calculation window, which contains a number of lighting units, general information, lumen method calculation, and lighting distribution of the hospital, illustrated in figure 6.8.

Figure (6.8): The interface of lighting calculations

The hospital data, lighting consumption, and lumen method calculations are displayed at the subsidiary window shown in figure 6.9.

Figure (6.9): General information of lighting calculations

Lumen method calculates the number of lighting units; the lighting units displayed at a new window illustrated in figure 6.10.

Figure (6.10): number of lighting fixtures

The power factor correction window is presented in figure 6.11. The window contains four sections:

1- General information

2- Capacitor bank required

3- Power factor saving opportunities

4- Power factor diagram

Figure (6.11): power factor improvement and its penalties payment

Capacitors bank required shown in figure 6.12.

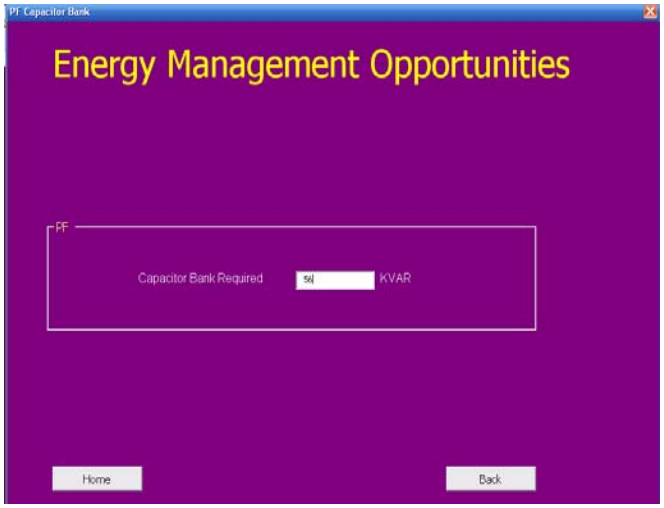


Figure (6.12): Capacitor bank required

Renewable energy can be employed in the hospitals' sector. Information data for calculating the quantity of hot water consumption and the savings are presented in figure 6.13.

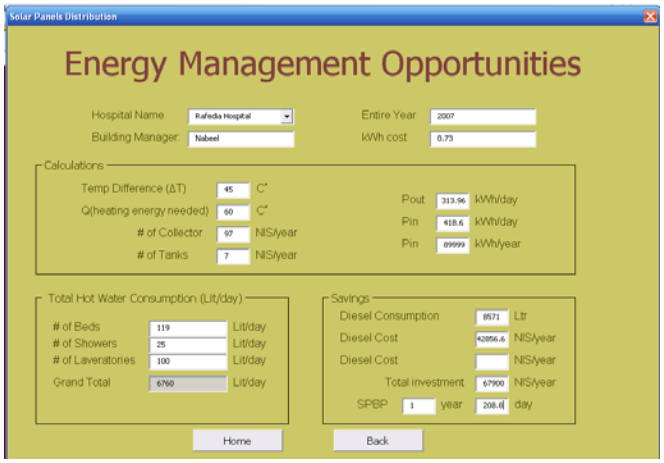


Figure (6.13): General data for calculating SWH

After inserting the general information about solar water heaters we attain to the distribution solar water heaters shown in figure 6.14

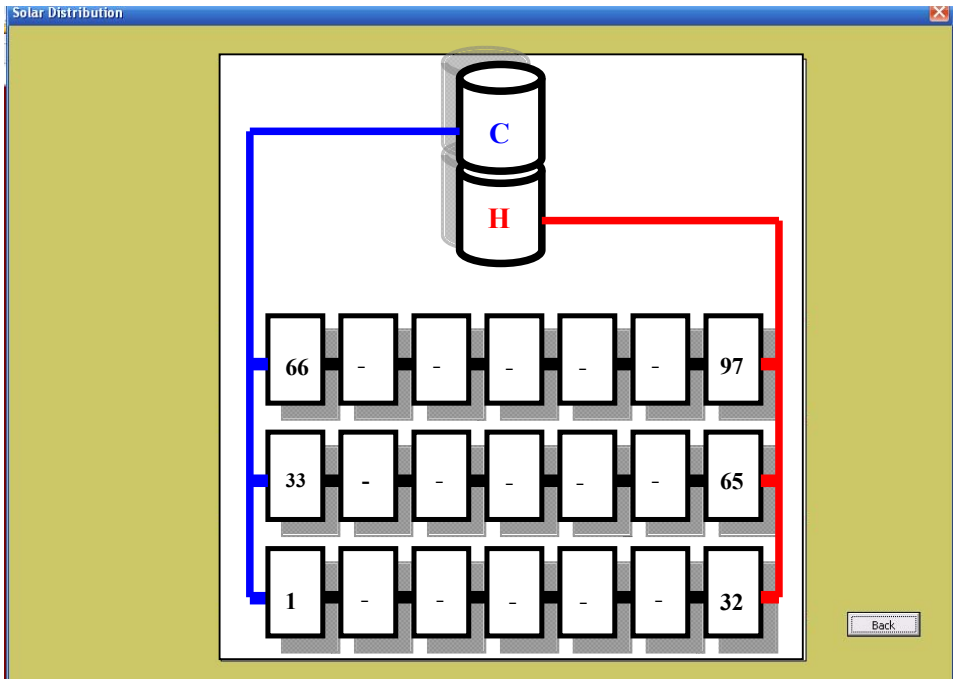


Figure (6.14): Number of solar collectors

To calculate the saving percentage in air-conditioning by controlling the inside thermostat of the room, we can show the steps in the following figure 6.15, which contains two windows: general information and saving calculations.

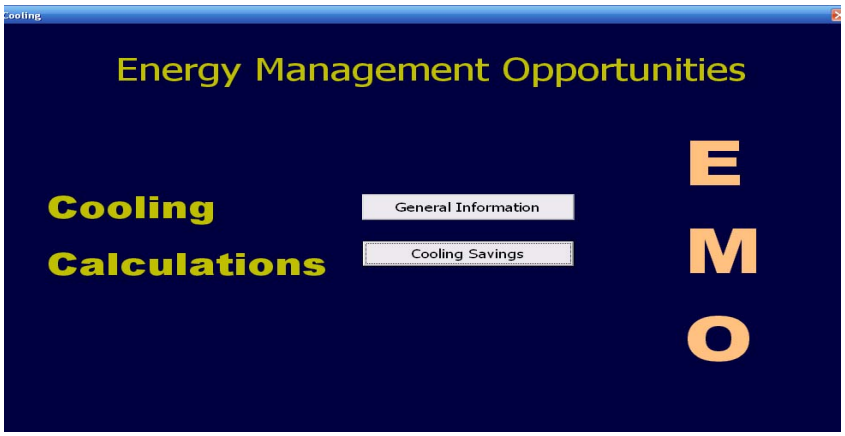


Figure (6.15): The interface of cooling calculations

Air-conditioning window general information can be inserted by pressing on the special icon as shown in figure 6.16

Figure (6.16): Air-conditioning window general information

The saving and the simple payback period can be achieved by pressing on its own button, as shown in figure 6.17.

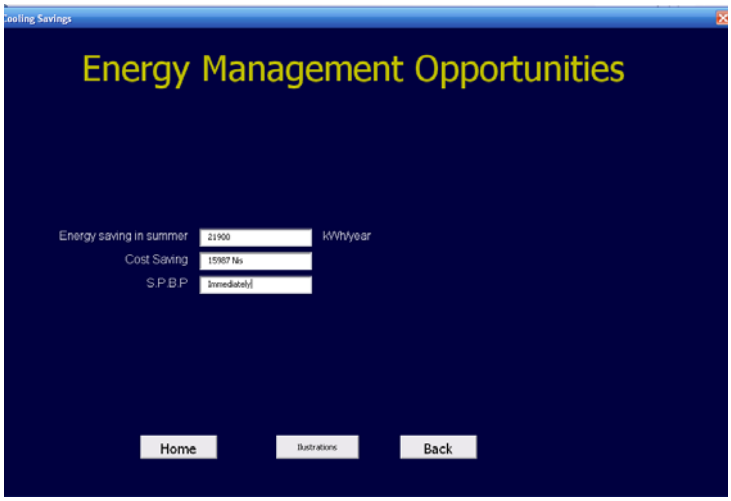


Figure (6.17): Air –conditioning saving

To improve the boiler efficiency in order to reduce the diesel consumption we can use the following window as shown in figure 6.18.

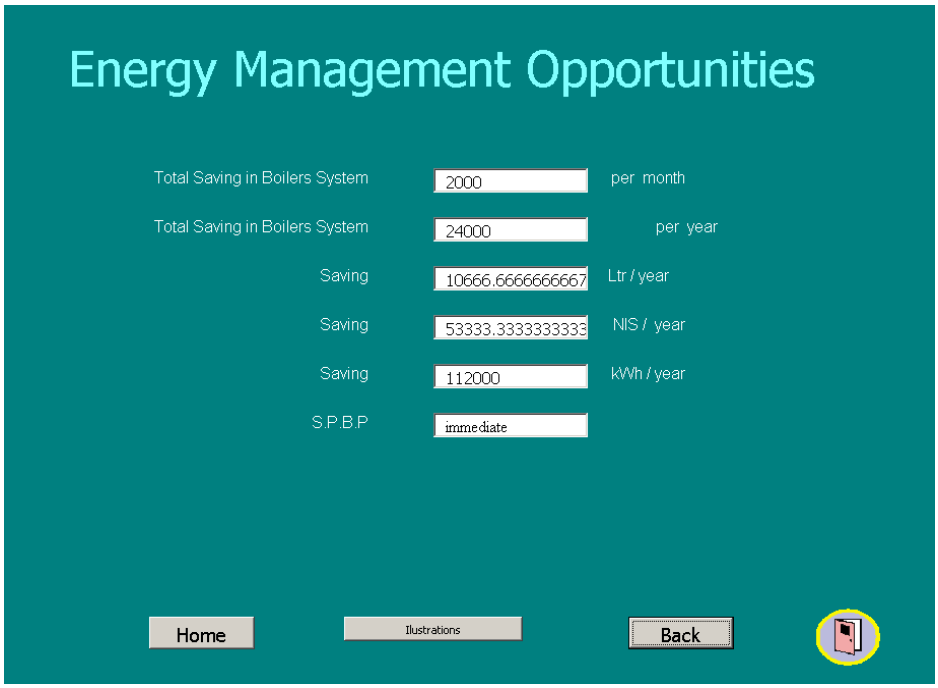


Figure (6.18): Boiler efficiency improvement

From the program oxygen can be achieved by inserting the general information in special window as shown in figure 6.19

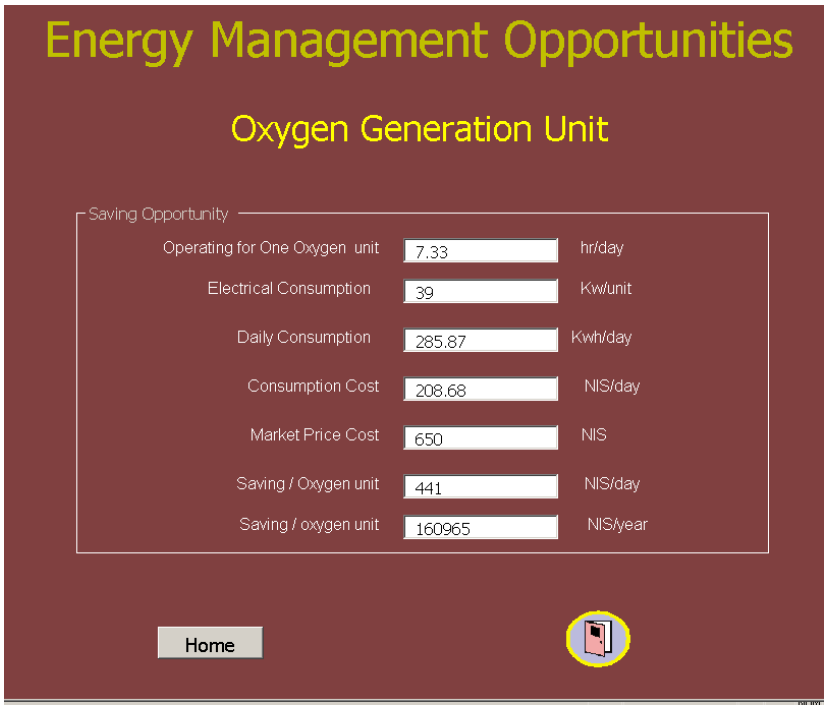


Figure (6.19): Oxygen generation window

6.6 Analysis and results

Using the analysis and calculations in chapter four, and comparing them with the programme designed for energy management opportunities in hospitals, it is noticeable that we achieve the same figures, and the same savings results accurately in short time.

Results show the application of proposed solutions and total annual savings, and simple payback period for each procedure. So the final stage is presented in printing the results.

Conclusions

The largest barrier to energy conservation in hospitals has been identified as lack of internal resources and lack of internal funding necessary to implement energy management programs and initiatives.

Hospitals are unique among serviceable sector in their intensity of energy use because of their 24-hour daily operation, special equipment usage, and environment comfort considerations. The efficient operation of hospitals, however, is vital to the health, security and safety of the community which they serve. An energy management program will help to insure the lowest possible costs of energy bills. Four hospitals have been chosen to take part in an experimental energy program. The goal of the program is reducing the end use of energy at these hospitals, and proving the audit concept to other hospitals in Palestine. An economic programme is implemented to produce huge results in energy conservation. It is acknowledged that energy wasting occurs throughout society.

Governmental hospitals are the largest in energy consumption; this can be seen in their electrical and non-electrical bills; due to lack of awareness and knowledge through energy efficiency and energy management well.

Identifying operation and maintenance (O&M) practices and energy conservation measures is particularly important in hospitals, because they are energy intensive. The audit focused primarily on- no and low- cost conservation practices and measures. The audit data collected and their analysis provide important information on ways to improve energy efficiency in hospitals and the economics of so doing.

It was proved and presented in this thesis that there is a great potential for energy savings in the Palestinian hospitals' sector by implementing energy conservation measures of no and low cost investment. Energy consumption in hospitals is huge due to non-awareness and lack of experience of energy management procedures; in addition to continous negligence of energy employment the hospitals are likewise old, thus inappropriate to implement energy conservation or management in their present conditions.

By implementing an energy audit on energy efficiency improvements, including numerous diversified measurements in hospitals' sectors, we proved that applying the mentioned energy conservation measures would undoubtedly save considerable amounts in the electrical energy bills and fuel.

Using efficient lighting devices, renewable energy such as solar water heaters instead of diesel boilers, improving the power factor, and adjusting properly the heating and air-condition thermostat can save in average 17% of energy consumption.

It is also recommended that an energy conservation fund should be set up to assist with financing future energy conservation related investments.

Recommendations

In order to encourage conservation in hospitals, direct action should be taken to reduce barriers to energy efficiency and also to offer incentive and facilitate conservation in hospitals. The recommendations are:

1. Increase awareness of energy issues and energy conservation within the professional, general public and legislators, by developing of governmental policies, regulations, provisions and incentives to encourage use and investment in solar thermal technologies.

2. Support and improve utilization of renewable energy sources especially of solar power as sunshine is abundant and clean source of energy.

3. Develop legal and legislative instruments by the Palestinian legislative council (PLC), and related ministries, and issue legal enforcement of energy codes and manual practices for energy conservation and efficiency.

4. Support the existing and new energy research and information centers to acquire the potentials in energy sector and to encourage investment and use of new technology and concepts of energy conservation and efficiency.

5. Introduce technical training for energy conservation practices to schools, vocational colleges and universities.

6. Introduce and develop training and knowledge of energy saving practices to the private sector, especially services.

7. Investigation into power factor correction. Improving power factor in hospitals reduces the electrical losses and increases electrical capacity in addition to avoiding of imposing penalties.

8. Improved house -keeping measures in lighting system such as;

   a. always turning lights off when they are not needed. This can be achieved by using stickers or reminders to make employees more aware.

   b. regular maintenance checks of the lighting especially cleaning of lamps to remove dirt.

9. Introducing automatic control systems, with light and or proximity sensors and time switches. These devices reduce energy consumption by limiting usage of lamps to those times when lighting is actually required, and available daylight is insufficient.

10. Where possible the use of daylight to maximize the advantage to reduce lighting should be encouraged.

11. Support pilot programs and projects in sustainable energy production, saving, and conservation within the existing energy sector.

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Appendices

Lighting Analysis at Arab Specialty Hospital

Appendix A

		Existing Condition							Recommended Condition			Saving	
Place	**Type**	**Number**	**Rating (W)**	**Annual operation hours**	**Load (kW)**	**Consumption (kWh)**	**Measured (LUX)**	**Standard (LUX)**	**Removed Lamps**	**Load (kW)**	**Consumption (kWh)**	**Load (kW)**	**Consumption (kWh)**
Laundry	FL	10	36	2000	0.720	1440	290	200	6	0.504	1008	0.216	432
Auto Clave	FL	4	36	3000	0.288	864	250	300	0	0.288	864	0	0
Kitchen	FL	6	36	3000	0.432	1296	280	300	0	0.432	1296	0	0
Kitchen Storage	FL	2	36	1500	0.144	216	150	200	0	0.144	216	0	0
Mechanical Room	FL	4	36	4000	0.288	1152	200	150	2	0.216	864	0.072	288
Parking	FL	13	36	4000	0.468	1872	300	150	5	0.288	1152	0.18	720
Electrical Room	FL	1	36	2000	0.036	72	100	150	0	0.036	72	0	0
Lobby	FL	3	36	4000	0.108	432	160	150	0	0.108	432	0	0
Corridor	FL	5	36	4000	0.18	720	250	150	5	0	0	0.18	720
Stairs	INC	7	60	3000	0.42	1260	320	150	4	0.18	540	0.24	720
X-Ray	FL	4	36	3500	0.144	504	300	200	2	0.072	252	0.072	252
Dark Room	FL	1	36	3000	0.036	108	180	200	0	0.036	108	0	0
Multi Purpose Hall	FL	10	36	4000	0.36	1440	450	300	10	0	0	0.36	1440
Lab	FL	6	36	5000	0.216	1080	700	600	4	0.072	360	0.144	720
Kitchen	FL	3	36	3000	0.216	648	350	300	1	0.18	540	0.036	108
Preparation	FL	4	36	3000	0.288	864	400	300	2	0.216	648	0.072	216
Lobby	FL	4	36	4000	0.144	576	280	150	2	0.072	288	0.072	288
Corridor	FL	6	18	4000	0.108	432	250	150	3	0.054	216	0.054	216
Lab	FL	4	36	5000	0.144	720	650	600	0	0.144	720	0	0
Cafeteria	FL	13	36	5000	0.468	2340	240	100	6	0.252	1260	0.216	1080

		Existing Condition							Recommended Condition			Saving	
Place	**Type**	**Number**	**Rating (W)**	**Annual operation hours**	**Load (kW)**	**Consumption (kWh)**	**Measured (LUX)**	**Standard (LUX)**	**Removed Lamps**	**Load (kW)**	**Consumption (kWh)**	**Load (kW)**	**Consumption (kWh)**
Gift Shop	FL	6	36	3000	0.216	648	350	200	4	0.072	216	0.144	432
Optics	FL	6	36	4000	0.216	864	375	300	2	0.144	576	0.072	288
Pharmacy	FL	8	36	3000	0.288	864	600	400	4	0.144	432	0.144	432
Reception	FL	9	18	4000	0.162	648	500	200	16	0.126	504	0.288	1152
W.C	INC	2	60	1500	0.12	180	120	100	0	0.12	180	0	0
Stairs	INC	7	60	3000	0.42	1260	320	150	4	0.12	540	0.24	720
Main Entrance	PL	6	13	3500	0.078	273	400	200	3	0.18	136.5	0.39	136.5
Treatment	FL	2	36	3000	0.072	216	270	300	0	0.072	216	0	0
Office	FL	2	36	3000	0.072	216	390	400	0	0.072	216	0	0
Visual	INC	2	60	3500	0.12	420	400	400	0	0.12	420	0	0
Laser	FL	2	36	2500	0.072	180	300	250	1	0.036	90	0.036	90
Refraction	FL	3	36	4000	0.108	432	360	300	1	0.072	2188	0.036	144
Examination	FL	3	36	3000	0.108	324	345	300	1	0.072	216	0.036	108
Clinic	FL	2	36	3000	0.072	216	185	200	0	0.072	216	0	0
Clinic	FL	3	36	3000	0.108	324	255	200	1	0.072	216	0.036	108
Clinic	FL	2	36	3000	0.072	216	195	200	0	0.072	216	0	0
Clinic	FL	2	36	3000	0.072	216	187	200	0	0.072	216	0	0
Clinic	FL	2	36	3000	0.072	216	250	200	1	0.036	108	0.036	108
Clinic	FL	2	36	3000	0.072	216	245	200	1	0.036	108	0.036	108
Clinic	FL	2	36	3000	0.072	216	240	200	1	0.036	108	0.036	108
Clinic	FL	2	36	3000	0.072	216	260	200	1	0.036	108	0.036	108

		Existing Condition							Recommended Condition			Saving	
Place	**Type**	**Number**	**Rating (W)**	**Annual operation hours**	**Load (kW)**	**Consumption (kWh)**	**Measured (LUX)**	**Standard (LUX)**	**Removed Lamps**	**Load (kW)**	**Consumption (kWh)**	**Load (kW)**	**Consumption (kWh)**
Office	FL	2	36	3000	0.072	216	340	400	0	0.072	216	0	0
Office	FL	2	36	3000	0.072	216	380	400	0	0.072	216	0	0
Office	FL	2	36	3000	0.072	216	400	400	0	0.072	216	0	0
Office	FL	2	36	3000	0.072	216	450	400	1	0.036	108	0.036	108
Office	FL	2	36	3000	0.072	216	395	400	0	0.072	216	0	0
Office	FL	2	36	3000	0.072	216	440	400	1	0.036	108	0.036	108
Educe	FL	2	36	4000	0.072	288	280	200	1	0.036	144	0.036	144
Records & Sec	FL	2	36	4000	0.072	288	370	300	1	0.036	144	0.036	144
Ophthalmic Ward	FL	4	36	3000	0.144	432	480	500	0	0.144	432	0	0
Corridor	FL	12	18	3000	0.216	648	330	150	16	0.072	216	0.288	864
Waiting	INC	9	18	4000	0.162	648	300	200	5	0.072	288	0.09	360
W.C	FL	2	60	3000	0.12	360	155	150	0	0.12	360	0	0
Stairs	INC	7	60	3000	0.42	1260	240	150	3	0.24	720	0.18	540
Theatre	FL	8	36	1500	0.288	432	320	200	4	0.144	216	0.144	216
Rest Room	FL	4	36	4000	0.144	576	280	200	2	0.072	288	0.072	288
Recovery	FL	5	36	3000	0.108	324	365	300	2	0.036	108	0.072	216
Nurse's Room	FL	2	36	3000	0.072	216	265	200	1	0.036	108	0.036	108
M. Chan	FL	2	36	3000	0.072	216	210	150	1	0.036	108	0.036	108
Lab	FL	6	18	5000	0.108	540	550	600	0	0.108	540	0	0
Semi Collection	FL	3	36	3000	0.108	324	370	300	1	0.072	216	0.036	108
Sweat	FL	2	36	4000	0.072	288	190	200	0	0.072	288	0	0

		Existing Condition							Recommended Condition			Saving	
Place	**Type**	**Number**	**Rating (W)**	**Annual operation hours**	**Load (kW)**	**Consumption (kWh)**	**Measured (LUX)**	**Standard (LUX)**	**Removed Lamps**	**Load (kW)**	**Consumption (kWh)**	**Load (kW)**	**Consumption (kWh)**
Clinic	FL	2	36	3000	0.072	216	310	200	2	0	0	0.072	216
Clinic	FL	3	36	3000	0.072	216	180	200	0	0.072	216	0	0
Clinic	FL	2	36	3000	0.072	216	150	200	0	0.072	216	0	0
Office	FL	2	36	3000	0.072	216	360	400	0	0.072	216	0	0
Office	FL	2	36	3000	0.072	216	450	400	2	0	0	0.072	216
Office	FL	2	36	3000	0.072	216	480	400	2	0	0	0.072	216
Storage Equipment	PL	2	36	2500	0.072	180	245	200	2	0	0	0.072	180
Corridor	FL	12	18	4000	0.216	864	330	150	12	0	0	0.216	864
Corridor	FL	4	36	4000	0.144	576	255	150	2	0.072	288	0.072	288
Waiting	INC	9	60	4000	0.540	2160	380	200	4	0.3	1200	0.240	960
F. Changing	FL	1	36	3000	0.036	108	270	300	0	0.036	108	0	0
Stairs	INC	7	60	3000	0.42	1260	250	150	3	0.24	720	0.180	540
Third Floor													
Theatre	FL	6	36	1500	0.216	324	300	200	3	0.108	162	0.108	162
Theatre	FL	8	36	1500	0.288	432	310	200	4	0.144	216	0.144	216
Theatre	FL	6	36	1500	0.216	324	285	200	4	0.072	108	0.144	216
Sterile Supply	FL	1	36	2500	0.072	180	370	400	0	0.072	180	0	0
Nurse's Room	FL	2	36	3000	0.072	216	176	200	0	0.072	216	0	0
Patient Room	FL	2	36	3000	0.072	216	230	200	1	0.036	108	0.036	108
Sweat	FL	2	36	4000	0.072	288	244	200	1	0.036	144	0.036	144
Patient Room	FL	2	36	3000	0.072	216	190	200	0	0.072	216	0	0
Patient Room	FL	2	36	3000	0.072	216	260	200	1	0.036	108	0.036	108

		Existing Condition							Recommended Condition			Saving	
Place	**Type**	**Number**	**Rating (W)**	**Annual operation hours**	**Load (kW)**	**Consumption (kWh)**	**Measured (LUX)**	**Standard (LUX)**	**Removed Lamps**	**Load (kW)**	**Consumption (kWh)**	**Load (kW)**	**Consumption (kWh)**
Patient Room	FL	2	36	3000	0.072	216	290	200	2	0	0	0.072	216
Patient Room	FL	2	36	3000	0.072	216	210	200	0	0.072	216	0	0
Patient Room	FL	2	36	3000	0.072	216	260	200	1	0.036	108	0.036	108
Staff Room	FL	2	36	3000	0.072	216	220	300	0	0.072	216	0	0
Registry Room	FL	2	36	2500	0.072	180	310	400	0	0.072	180	0	0
Waiting	FL	6	36	4000	0.216	864	280	200	2	0.144	576	0.072	288
Corridor	FL	10	18	4000	0.18	720	300	150	10	0	0	0.18	720
Corridor	FL	3	36	4000	0.108	432	270	150	1	0.072	288	0.036	144
Lobby	FL	4	36	4000	0.144	576	190	150	1	0.108	432	0.036	144
F. Changing	FL	1	36	3000	0.036	108	150	300	0	0.036	108	0	0
Stairs	INC	7	60	3000	0.42	1260	210	150	3	0.24	720	0.18	540
Roof Floor													
Chiller Room	FL	4	36	1500	0.144	216	220	150	1	0.108	162	0.036	54
Stairs	INC	7	60	3000	0.42	1260	250	150	4	0.18	540	0.24	720
Total						**49869**						**6.615**	**21922.5**

Total Load **Total Saving**

Total Saving = 21,922.5 kWh x 0.73 NIS/kWh = 16,003.425 NIS

Lighting Analysis at Rafidiah Hospital
(Appendix B)

	Existing Conditions								Recommended Conditions				Saving	
Place	Type	Rating (W)	No.	Annual operating hours	Load (kW)	Consmption (kWh)	Measured Lux	Standard Lux	Removed lamp	Replaced lamps	Load kW	Consmption (kWh)	Load (kW)	Consump-tion (kWh)
Lobby-corridor	FL	36	26	4000	0.936	3744	115	150	0	0	0.936	3744	0	0
Boiler room	FL	36	4	4000	0.144	576	100	200	0	0	0.144	576	0	0
Waiting hall	FL	40	50	3000	2	6000	118	200	0	50(FL40-FL36)	1.8	5400	0.2	600
Emergency-Ex corridor	FL	40	12	4000	0.48	1920	320	150	6	6(FL40-FL36)	0.216	864	0.264	1056
The Mosque	FL	40	4	4000	0.16	640	64	100	0	4(FL40-FL36)	0.144	576	0.016	64
Waiting hall-internal	FL	36	24	3000	0.864	2592	115	200	0	0	0.864	2592	0	0
Pharmacy corridor	FL	36	7	4000	0.252	1008	190	150	3	4(FL40-FL36)	0.144	576	0.108	432
Pharmacy	FL	40	15	4000	0.6	2400	318	300	0	15(FL40-FL36)	0.54	2160	0.06	240
Pharmacist office	FL	36	2	4000	0.072	288	390	400	0	0	0.072	288	0	0
Clinics lobby-corridor	FL	40	20	4000	0.8	3200	145	150	0	20(FL40-FL36)	0.72	2880	0.08	320
Waiting hall	FL	36	12	4000	0.432	1728	90	200	0	0	0.432	1728	0	0
Account corridor	FL	36	11	4000	0.396	1584	185	150	3	8(FL40-FL36)	0.288	1152	0.108	432
Blood Bank corridor	FL	40	3	4000	0.12	480	85	150	0	3(FL40-FL36)	0.108	432	0.012	48
Lab.Waiting room	FL	36	6	4000	0.216	864	170	200	0	0	0.216	864	0	0
Main lab.	FL	36	36	5000	1.296	6480	620	600	0	0	1.296	6480	0	0
Lab.-Internal corridor 1	FL	36	4	5000	0.144	720	370	150	2	0	0.072	360	0.072	360
Lab.-Internal room	FL	36	2	5000	0.072	360	325	300	0	0	0.072	360	0	0
Lab.-Internal room	FL	36	4	5000	0.144	720	275	300	0	0	0.144	720	0	0
Lab.-Internal room	FL	36	4	5000	0.144	720	240	300	0	0	0.144	720	0	0
Blood Offering room	FL	36	6	3000	0.216	648	250	300	0	0	0.216	648	0	0
Lab.-Internal	FL	36	12	4000	0.432	1728	150	150	0	0	0.432	1728	0	0

corridor 2														
WC-Lab.	FL	40	1	1500	0.04	60	370	100	0	1(FL40-FL36)	0.036	54	0.004	6
WC-Blood Bank	FL	36	2	1500	0.072	108	145	100	0	0	0.072	108	0	0
Women Mosque	FL	40	2	3000	0.08	240	45	100	0	2(FL40-FL36)	0.072	216	0.018	24
Stairs	FL	36	4	3000	0.144	432	175	150	1	0	0.108	324	0.036	108
Elevator corridor	FL	36	8	4000	0.288	1152	80	150	0	0	0.288	1152	0	0
Ambulance corridor	FL	40	14	4000	0.56	2240	130	150	0	14(FL40-FL36)	0.504	2016	0.056	224
Emergency-l corridor	FL	36	20	4000	0.72	2880	235	150	6	0	0.504	2016	0.216	864
Emergency	FL	36	24	4000	0.864	3456	630	500	4	0	0.72	2880	0.144	576
Ambulance Archive	FL	40	8	4000	0.32	1280	300	300	0	8(FL40-FL36)	0.288	1152	0.032	128
Medicines room	FL	40	1	3500	0.04	140	120	300	0	1(FL40-FL36)	0.036	126	0.004	14
Gibs room	FL	40	2	4000	0.08	320	400	400	0	2(FL40-FL36)	0.072	288	0.008	32
Ambulance main entrance	FL	36	6	4000	0.216	864	150	150	0	0	0.216	864	0	0
Information Office	FL	36	2	4000	0.072	288	180	300	0	0	0.072	288	0	0
Information Office-rest room	FL	36	2	3000	0.072	216	270	200	0	0	0.072	216	0	0
The Central-hospital entrance	FL	36	2	4000	0.072	288	270	200	0	0	0.072	288	0	0
The Central-l entrance	lNC	60	5	4000	0.3	1200	100	150	0	5(lNC 60-CFL15)	0.075	300	0.225	900
Security room	FL	36	2	4000	0.072	288	340	300	0	0	0.072	288	0	0
X-Ray corridor	FL	36	8	4000	0.288	1152	155	150	0	0	0.288	1152	0	0
X-Ray Room	FL	40	6	3500	0.24	840	75	200	0	6(FL40-FL36)	0.216	756	0.024	84
X-Ray-WC	lNC	60	2	1500	0.12	180	90	100	0	2(lNC 60-CFL15)	0.03	45	0.09	135
Changing room	lNC	60	1	3500	0.06	210	110	200	0	1(lNC 60-CFL15)	0.015	52.5	0.045	157.5
The Archive	FL	40	12	3000	0.48	1440	140	300	0	12(FL40-FL36)	0.432	1296	0.048	144
Tahmid room	FL	40	6	3000	0.24	720	300	300	0	6(FL40-FL36)	0.216	756	0.024	72
X-Ray Room(21)	FL	40	16	3500	0.64	2240	500	300	0	10(FL40-FL36)	0.36	1260	0.28	980
X-Ray Room(21)-WC	lNC	60	2	1500	0.12	180	90	100	6	2(lNC 60-CFL15)	0.03	45	0.09	135
Changing room	lNC	60	1	3000	0.06	180	105	200	0	1(lNC 60-CFL15)	0.015	45	0.045	135
X-Ray Room(3)	FL	40	10	3000	0.4	1200	103	300	0	10(FL40-FL36)	0.36	1080	0.04	120

X-Ray Room(3)-WC	lNC	60	1	1500	0.06	90	90	100	0	1 (lNC 60-CFL15)	0.015	22.5	0.045	67.5
Changing room	lNC	60	1	4000	0.06	240	105	200	0	1 (lNC 60-CFL15)	0.015	60	0.045	180
Scan office	FL	20	8	3000	0.16	480	300	400	0	8(FL20-FL18)	0.144	432	0.016	48
Scan room	FL	20	16	3000	0.32	960	250	300	0	16(FL20-FL18)	0.288	864	0.032	96
Ultrasonic room	FL	40	6	3000	0.24	720	240	300	0	6(FL40-FL36)	0.216	648	0.024	72
Physical therapy	FL	40	8	3000	0.32	960	95	200	0	8(FL40-FL36)	0.288	864	0.032	96
Stairs	lNC	60	7	3000	0.42	1680	50	150	0	7(lNC 60-CFL15)	0.105	315	0.315	945
Room-1	FL	40	2	3000	0.08	240	175	200	0	2(FL40-FL36)	0.072	216	0.008	24
Room-2	FL	40	4	3000	0.16	480	140	200	0	4(FL40-FL36)	0.144	432	0.016	48
Corridor	FL	20	24	4000	0.48	1920	300	150	12	12(FL20-FL18)	0.216	864	0.264	1056
Nursing office	FL	40	4	3500	0.16	560	336	300	0	4(FL40-FL36)	0.144	504	0.016	56
Room-3	FL	40	4	3500	0.16	560	200	200	0	4(FL40-FL36)	0.144	504	0.016	56
Burning-changing room	FL	40	6	3000	0.24	720	70	300	0	6(FL40-FL36)	0.216	648	0.024	72
Burning-room 1	FL	40	6	3000	0.24	720	200	300	0	6(FL40-FL36)	0.216	648	0.024	72
Burning-room 2	FL	40	6	3000	0.24	720	230	300	0	6(FL40-FL36)	0.216	648	0.024	72
Burning-WC	FL	40	4	1500	0.16	240	128	100	0	4(FL40-FL36)	0.144	216	0.016	24
WC	lNC	60	4	1500	0.24	360	85	100	0	4(lNC 60-CFL15)	0.06	90	0.18	270
Elevator corridor	FL	40	12	4000	0.48	1920	75	150	0	12(FL40-FL36)	0.432	1728	0.048	192
Entrance	FL	40	4	3500	0.16	560	300	200	2	2(FL40-FL36)	0.072	252	0.088	308
Corridor	FL	36	14	4000	0.504	2016	220	150	4	10(FL40-FL36)	0.36	1440	0.144	576
Rest room	FL	40	3	4000	0.12	480	196	200	0	3(FL40-FL36)	0.108	432	0.012	48
Medicines room	FL	40	2	3000	0.08	240	160	300	0	2(FL40-FL36)	0.072	216	0.008	24
Recovery room	FL	20	36	3500	0.72	2520	140	200	10	26(FL20-FL18)	0.468	1638	0.252	882
Operation room-3	FL	36	6	3000	0.216	648	170	400	0	0	0.216	648	0	0
Lobby-corridor	FL	20	20	3000	0.4	1200	700	200	10	10(FL20-FL18)	0.18	540	0.22	660
Operation room-1	FL	20	48	3000	0.96	2880	225	400	0	48(FL20-FL18)	0.864	2592	0.096	288
Operation room-2	FL	20	48	3000	0.96	2880	225	400	0	48(FL20-FL18)	0.864	2592	0.096	288
WC	iNC	60	2	1500	0.12	180	81	100	0	2(lNC 60-CFL15)	0.03	45	0.09	135
Equipment Store	FL	36	2	2500	0.072	180	145	200	0	0	0.072	180	0	0
Washing basin	FL	36	2	3000	0.072	216	260	200	1	0	0.036	108	0.036	108
Instruments Store	FL	36	4	2500	0.144	360	230	200	0	0	0.144	360	0	0

Doctors office	**FL**	**36**	**4**	**3000**	**0.144**	**432**	**240**	**300**	**0**	**0**	**0.144**	**432**	**0**	**0**
Female changing room	**FL**	**36**	**3**	**3000**	**0.108**	**324**	**285**	**300**	**0**	**0**	**0.108**	**324**	**0**	**0**
Male changing room	**FL**	**36**	**2**	**3000**	**0.072**	**216**	**265**	**300**	**0**	**0**	**0.072**	**216**	**0**	**0**
Room	**FL**	**36**	**40**	**3000**	**1.2**	**4320**	**395**	**200**	**10**	**0**	**1.08**	**3240**	**0.12**	**360**
Changing rooms lobby	**FL**	**36**	**1**	**3000**	**0.036**	**108**	**270**	**200**	**0**	**0**	**0.036**	**108**		
Management corridor	**FL**	**40**	**17**	**4000**	**0.68**	**2720**	**280**	**150**	**7**	**10(FL40-FL36)**	**0.36**	**1440**	**0.32**	**1280**
WC corridor	**FL**	**36**	**3**	**2000**	**0.108**	**216**	**400**	**150**	**2**	**0**	**0.036**	**72**	**0.072**	**144**
WC	**iNC**	**60**	**3**	**1500**	**0.18**	**270**	**195**	**100**	**0**	**3(lNC 60-CFL15)**	**0.045**	**67.5**	**0.135**	**202.5**
Management stairs	**FL**	**40**	**3**	**4000**	**0.12**	**480**	**170**	**150**	**0**	**3(FL40-FL36)**	**0.108**	**432**	**0.012**	**48**
Corridor	**FL**	**36**	**6**	**4000**	**0.216**	**864**	**197**	**150**	**2**	**0**	**0.144**	**576**	**0.072**	**288**
Office	**FL**	**36**	**4**	**3000**	**0.144**	**432**	**310**	**400**	**0**	**0**	**0.144**	**432**	**0**	
Room-1	**FL**	**36**	**6**	**3000**	**0.216**	**648**	**300**	**200**	**2**	**0**	**0.144**	**432**	**0.072**	**216**
Nursing office	**FL**	**40**	**2**	**3000**	**0.08**	**240**	**150**	**300**	**0**	**2(FL40-FL36)**	**0.072**	**216**	**0.008**	**24**
Room-2	**FL**	**40**	**2**	**3000**	**0.08**	**480**	**45**	**200**	**0**	**2(FL40-FL36)**	**0.072**	**216**	**0.008**	**24**
Corridor	**FL**	**18**	**36**	**4000**	**0.648**	**2592**	**180**	**150**	**6**	**0**	**0.54**	**2160**	**0.108**	**432**
Room-4*3	**FL**	**36**	**4*3**	**3000**	**0.432**	**1296**	**300**	**200**	**3**	**0**	**0.324**	**970**	**0.108**	**324**
ICU	**FL**	**40**	**8**	**4000**	**0.32**	**1280**	**280**	**400**	**0**	**8(FL40-FL36)**	**0.288**	**1152**	**0.032**	**128**
ICU—Medicines room	**FL**	**40**	**4**	**3000**	**0.16**	**480**	**260**	**300**	**0**	**4(FL40-FL36)**	**0.144**	**432**	**0.016**	**48**
WC*2	**FL**	**40**	**1*2**	**1500**	**0.08**	**120**	**200**	**100**	**0**	**2(FL40-FL36)**	**0.072**	**108**	**0.008**	**12**
ICU—Entrance	**FL**	**40**	**2**	**4000**	**0.08**	**320**	**145**	**150**	**0**	**2(FL40-FL36)**	**0.072**	**288**	**0.008**	**32**
WC-corridor	**FL**	**40**	**1**	**4000**	**0.04**	**160**	**160**	**150**	**0**	**1(FL40-FL36)**	**0.036**	**144**	**0.004**	**16**
WC	**iNC**	**60**	**9**	**1500**	**0.54**	**810**	**55**	**100**	**0**	**9(lNC 60-CFL15)**	**0.135**	**202.5**	**0.405**	**607.5**
Stairs	**FL**	**40**	**1**	**4000**	**0.04**	**160**	**50**	**150**	**0**	**1(FL40-FL36)**	**0.036**	**144**	**0.004**	**16**
Second floor-Elevator corridor	**FL**	**36**	**8**	**3000**	**0.288**	**864**	**430**	**200**	**4**	**0**	**0.144**	**432**	**0.144**	**432**
Maternity section corridor	**FL**	**36**	**14**	**3000**	**0.504**	**1512**	**400**	**150**	**4**	**0**	**0.36**	**1080**	**0.144**	**432**
Maternity section-	**FL**	**40**	**12**	**3000**	**0.48**	**1440**	**120**	**150**	**0**	**12(FL40-FL36)**	**0.432**	**1296**	**0.048**	**144**

internal corridor 1														
Incubator office	**FL**	**40**	**4**	**3000**	**0.16**	**480**	**297**	**300**	**0**	**4(FL40-FL36)**	**0.144**	**432**	**0.016**	**48**
Incubator WC	**iNC**	**60**	**9**	**1500**	**0.54**	**810**	**55**	**100**	**0**	**9(lNC 60-CFL15)**	**0.135**	**202.5**	**0.405**	**607.5**
WC corridor	**FL**	**40**	**2**	**3000**	**0.08**	**240**	**155**	**150**	**0**	**2(FL40-FL36)**	**0.072**	**216**	**0.008**	**24**
Maternity section-internal corridor 2	**FL**	**40**	**5**	**4000**	**0.2**	**800**	**485**	**150**	**3**	**2(FL40-FL36)**	**0.072**	**288**	**0.128**	**512**
Patient room *2	**FL**	**40**	**4*2**	**3000**	**0.32**	**960**	**108**	**200**	**0**	**8(FL40-FL36)**	**0.288**	**864**	**0.032**	**96**
Patient room *3	**FL**	**40**	**6*3**	**3000**	**0.72**	**2160**	**190**	**200**	**0**	**18(FL40-FL36)**	**0.648**	**1944**	**0.072**	**216**
Nursing room	**FL**	**40**	**2**	**3000**	**0.08**	**240**	**154**	**200**	**0**	**2(FL40-FL36)**	**0.072**	**216**	**0.008**	**24**
WC*5	**lNC**	**60**	**2*5**	**1500**	**0.6**	**900**	**96**	**100**	**0**	**10(lNC 60-CFL15)**	**0.15**	**225**	**0.45**	**675**
Elevator	**FL**	**20**	**4**	**4000**	**0.08**	**320**	**100**	**100**	**0**	**4(FL20-FL18)**	**0.072**	**288**	**0.008**	**32**
Female surgery room	**FL**	**40**	**1**	**3000**	**0.04**	**120**	**150**	**400**	**0**	**(FL40-FL36)**	**0.036**	**108**	**0.004**	**12**
Female surgery corridor	**FL**	**40**	**10**	**2000**	**0.4**	**800**	**95**	**150**	**0**	**10(FL40-FL36)**	**0.36**	**720**	**0.04**	**80**
Patient room * 4	**FL**	**36**	**4*4**	**3000**	**0.576**	**1728**	**365**	**200**	**8**	**0**	**0.288**	**864**	**0.288**	**864**
Patient room	**FL**	**36**	**3**	**3000**	**0.108**	**324**	**305**	**200**	**1**	**0**	**0.072**	**216**	**0.036**	**108**
Washing room	**lNC**	**60**	**3**	**2000**	**0.18**	**360**	**55**	**200**	**0**	**3(lNC 60-CFL15)**	**0.045**	**90**	**0.135**	**270**
Corridor	**FL**	**36**	**4**	**4000**	**0.144**	**576**	**115**	**154**	**0**	**0**	**0.144**	**576**	**0**	**0**
Washing room in corridor	**FL**	**36**	**1**	**2000**	**0.036**	**72**	**80**	**200**	**0**	**0**	**0.036**	**72**	**0**	**0**
Elevator corridor	**FL**	**40**	**10**	**4000**	**0.4**	**1600**	**152**	**150**	**0**	**10(FL40-FL36)**	**0.36**	**1440**	**0.04**	**160**
Male surgery corridor	**FL**	**36**	**8**	**4000**	**0.288**	**1152**	**93**	**150**	**0**	**0**	**0.288**	**1152**	**0**	**0**
Patient room –(3 beds)	**FL**	**36**	**2**	**3000**	**0.072**	**216**	**185**	**200**	**0**	**0**	**0.072**	**216**	**0**	**0**
Patient room –(4 beds)	**FL**	**40**	**2**	**3000**	**0.08**	**240**	**107**	**200**	**0**	**2(FL40-FL36)**	**0.072**	**216**	**0.008**	**24**
Patient room –(5 beds)	**FL**	**36**	**2**	**3000**	**0.072**	**216**	**107**	**200**	**0**	**0**	**0.072**	**216**	**0**	**0**
Patient room –(6 beds)	**FL**	**36**	**2**	**3000**	**0.072**	**216**	**170**	**200**	**0**	**0**	**0.072**	**216**	**0**	**0**

Patient room (7 beds)	**FL**	**36**	**3**	**3000**	**0.108**	**324**	**220**	**200**	**0**	**0**	**0.108**	**324**	**0**	**0**
Nursing room	**FL**	**36**	**4**	**3000**	**0.144**	**432**	**335**	**400**	**0**	**0**	**0.144**	**432**	**0**	**0**
WC * 8	**lNC**	**60**	**8*1**	**1500**	**0.48**	**720**	**45**	**100**	**0**	**8(lNC 60-CFL15)**	**0.12**	**180**	**0.36**	**540**
Room	**FL**	**36**	**2**	**3000**	**0.072**	**216**	**280**	**200**	**0**	**0**	**0.072**	**216**	**0**	**0**
Male surgery-Stairs	**FL**	**36**	**2**	**3000**	**0.072**	**216**	**100**	**150**	**0**	**0**	**0.072**	**216**	**0**	**0**
Waiting hall	**FL**	**40**	**11**	**4000**	**0.44**	**1760**	**250**	**200**	**3**	**8(FL40-FL36)**	**0.288**	**1152**	**0.152**	**608**
WC * 4	**lNC**	**60**	**4*1**	**1500**	**0.24**	**360**	**180**	**100**	**0**	**4(lNC 60-CFL15)**	**0.06**	**90**	**0.18**	**270**
Kitchen corridor *2	**FL**	**40**	**1*2**	**2000**	**0.08**	**160**	**100**	**150**	**0**	**2(FL40-FL36)**	**0.072**	**144**	**0.008**	**32**
Patient room *8	**FL**	**40**	**8*2**	**3000**	**0.64**	**1920**	**270**	**200**	**0**	**16(FL40-FL36)**	**0.576**	**1728**	**0.064**	**192**
Personnel office	**FL**	**40**	**8**	**2500**	**0.32**	**800**	**600**	**500**	**2**	**6(FL40-FL36)**	**0.216**	**540**	**0.104**	**260**
Nurses manager office	**FL**	**40**	**8**	**2500**	**0.32**	**800**	**450**	**400**	**2**	**6(FL40-FL36)**	**0.216**	**540**	**0.104**	**260**
Administrative manager secretary	**FL**	**40**	**8**	**2500**	**0.32**	**800**	**450**	**400**	**2**	**6(FL40-FL36)**	**0.216**	**540**	**0.104**	**80**
Administrative manager office	**FL**	**40**	**8**	**2500**	**0.32**	**800**	**310**	**500**	**0**	**8(FL40-FL36)**	**0.288**	**720**	**0.032**	**40**
Medical manager secretary office	**FL**	**40**	**4**	**2500**	**0.16**	**400**	**290**	**400**	**0**	**4(FL40-FL36)**	**0.144**	**360**	**0.016**	**260**
Medical manager office	**FL**	**40**	**8**	**2500**	**0.32**	**800**	**600**	**500**	**2**	**6(FL40-FL36)**	**0.216**	**540**	**0.104**	**260**
Medical vice office	**FL**	**40**	**8**	**2500**	**0.32**	**800**	**650**	**500**	**2**	**6(FL40-FL36)**	**0.216**	**540**	**0.104**	**260**
Lectures hall	**FL**	**40**	**14**	**2500**	**0.56**	**1400**	**670**	**500**	**4**	**10(FL40-FL36)**	**0.36**	**900**	**0.2**	**500**
Copy machine room	**lNC**	**60**	**1**	**2000**	**0.06**	**120**	**145**	**200**	**0**	**1(lNC 60-CFL15)**	**0.015**	**22.5**	**0.045**	**67.5**
Kitchen	**FL**	**40**	**66**	**3000**	**2.64**	**7920**	**350**	**300**	**10**	**56(FL40-FL36)**	**0.016**	**6048**	**0.624**	**1872**
Eating hall	**FL**	**40**	**52**	**2000**	**2.08**	**4160**	**320**	**200**	**17**	**35(FL40-FL36)**	**1.26**	**2520**	**0.82**	**1640**
WC –entrance	**FL**	**10**	**6**	**2500**	**0.06**	**150**	**300**	**150**	**2**	**0**	**0.04**	**100**	**0.02**	**50**
WC*2	**FL**	**36**	**2*2**	**1500**	**0.144**	**216**	**240**	**100**	**2**	**0**	**0.072**	**108**	**0.072**	**108**

X-Ray registering office	**FL**	**36**	**12**	**3000**	**0.432**	**1296**	**180**	**300**	**0**	**0**	**0.432**	**1296**	**0**	**0**
Maint. Engineer Office	**FL**	**36**	**8**	**3000**	**0.288**	**864**	**910**	**500**	**4**	**0**	**0.144**	**432**	**0.144**	**864**
Birth declaration	**FL**	**36**	**8**	**2500**	**0.288**	**720**	**500**	**400**	**2**	**0**	**0.216**	**540**	**0.072**	**180**
Accountant	**FL**	**36**	**8**	**3000**	**0.288**	**846**	**590**	**500**	**2**	**0**	**0.216**	**684**	**0.072**	**216**
Registration office	**FL**	**36**	**8**	**2500**	**0.288**	**720**	**420**	**400**	**2**	**0**	**0.216**	**540**	**0.072**	**180**
Accounting section head	**FL**	**36**	**7**	**3000**	**0.288**	**864**	**410**	**500**	**0**	**0**	**0.288**	**864**	**0**	**0**
Ext. Clinics office	**FL**	**36**	**14**	**3000**	**0.252**	**756**	**360**	**400**	**0**	**0**	**0.252**	**756**	**0**	**0**
Waiting hal	**FL**	**40**	**3**	**3000**	**0.56**	**1680**	**180**	**200**	**0**	**14(FL40-Fl36)**	**0.504**	**1512**	**0.056**	**168**
Pharmasy	**FL**	**40**	**2**	**3000**	**0.12**	**360**	**460**	**400**	**0**	**3(FL40-Fl36)**	**0.108**	**324**	**0.012**	**36**
Bathology Lab entrance	**FL**	**40**	**2**	**4000**	**0.08**	**320**	**400**	**200**	**1**	**1(FL40-Fl36)**	**0.036**	**144**	**0.044**	**176**
Dr. rest room	**FL**	**36**	**2**	**2000**	**0.072**	**144**	**530**	**200**	**1**	**0**	**0.036**	**72**	**0.036**	**72**
Section Secretary	**FL**	**40**	**4**	**2500**	**0.08**	**200**	**520**	**400**	**0**	**2(FL40-Fl36)**	**0.072**	**180**	**0.008**	**20**
Work shop 1	**FL**	**36**	**4**	**2500**	**0.144**	**360**	**300**	**300**	**0**	**0**	**0.144**	**360**	**0**	**0**
Work shop 2	**FL**	**36**	**4**	**2500**	**0.144**	**360**	**300**	**300**	**0**	**0**	**0.144**	**360**	**0**	**0**
Sewing workshop	**FL**	**36**	**4**	**2500**	**0.144**	**360**	**450**	**500**	**0**	**0**	**0.144**	**360**	**0**	**0**
Carpentry	**FL**	**36**	**2**	**2500**	**0.144**	**360**	**290**	**400**	**0**	**0**	**0.144**	**360**	**0**	**0**
Sterilization	**FL**	**40**	**3**	**2500**	**0.08**	**200**	**360**	**400**	**0**	**2(FL40-Fl36)**	**0.072**	**180**	**0.008**	**20**
Arsheef stairs	**FL**	**36**	**2**	**2500**	**0.108**	**270**	**210**	**150**	**1**	**0**	**0.072**	**180**	**0.036**	**90**
Total					**51.272**	**163392**							**11.735**	**35000**

Lighting Analysis at Ittihad Hospital
(Appendix C)

		Existing Condition							Recommended Condition			Saving	
Place	**Type**	**Number**	**Rating (W)**	**Annual operation hours**	**Load (kW)**	**Consumption (kWh)**	**Measured (LUX)**	**Standard (LUX)**	**Removed Lamps**	**Load (kW)**	**Consumption (kWh)**	**Load (kW)**	**Consumption (kWh)**
Corridor	FL	24	36	7000	0.864	6048	250	150	8	0.576	4032	0.288	2016
Operation corridor	FL	24	36	7000	0.864	6048	200	150	4	0.72	5040	0.144	1008
Corridor S5	FL	108	36	7000	3.888	27216	350	150	40	2.448	17136	1.440	10080
Kids Corridor	FL	54	36	7000	1.944	13608	300	150	16	1.368	9576	0.576	4032
Main entrance	FL	40	18	8000	0.72	5760	400	200	10	0.54	4320	0.180	1440
warehouse	FL	16	36	2500	0.576	1440	280	150	6	0.36	900	0.216	540
Room 1	FL	4	36	5500	0.144	792	440	300	2	0.072	396	0.072	396
Room 2	FL	4	36	5500	0.144	792	400	300	2	0.072	396	0.072	396
Room 3	FL	4	36	5500	0.144	792	420	300	2	0.072	396	0.072	396
Room 4	FL	4	36	5500	0.144	792	460	300	2	0.072	396	0.072	396
Room 5	FL	4	36	5500	0.144	792	380	300	0	0.144	792	0	0
Corridor	FL	40	18	8000	0.72	5760	240	150	10	0.54	4320	0.180	1440
Breeding Corridor	FL	16	36	7000	0.576	4032	200	150	4	0.432	3024	0.144	1008
Main entrance	FL	80	18	8000	1.44	1152	240	200	20	1.08	-1728	0.360	2880
Room 1	FL	4	36	5500	0.144	792	340	300	0	0.144	792	0	0
Room 2	FL	4	36	5500	0.144	792	290	300	0	0.144	792	0	0
Room 3	FL	4	36	5500	0.144	792	450	300	2	0.072	396	0.072	396
Room 4	FL	4	36	5500	0.144	792	430	300	2	0.072	396	0.072	396
Room 5	FL	4	36	5500	0.144	792	430	300	2	0.072	396	0.072	396
Room 6	FL	4	36	5500	0.144	792	380	300	2	0.072	396	0.072	396
Room 7	FL	4	36	5500	0.144	792	390	300	2	0.072	396	0.072	396

		Existing Condition							Recommended Condition			Saving	
Place	**Type**	**Number**	**Rating (W)**	**Annual operation hours**	**Load (kW)**	**Consumption (kWh)**	**Measured (LUX)**	**Standard (LUX)**	**Removed Lamps**	**Load (kW)**	**Consumption (kWh)**	**Load (kW)**	**Consumption (kWh)**
Room 8	FL	4	36	5500	0.144	792	480	300	2	0.072	396	0.072	2016
Room 9	FL	4	36	5500	0.144	792	500	300	2	0.072	396	0.072	1008
Kitchen	FL	8	18	6000	0.144	864	800	500	2	0.108	648	0.036	10080
Kitchen corridor	FL	44	36	7000	1.584	11088	330	150	20	0.864	6048	0.720	4032
Total					**15.336**	**94104**						**5.076**	**34056**

Lighting Analysis at Watani Hospital
(Appendix D)

Place	Existing Conditions						Recommended Conditions			Saving	
	Type	Rating (W)	Number	Annual operating hours	Load (kW)	Consump-tion (kWh)	Replaced lamps	Load kW	Consump-tion (kWh)	Load (kW)	Consump-tion (kWh)
Store	FL	40	9	2500	0.36	900	FL - 36	0.324	810	0.036	90
Design S.	FL	40	13	2500	0.52	1300	FL - 36	0.468	1170	0.052	130
Design S.	Inc.	60	3	2000	0.18	360	CFL - 15	0.045	90	0.135	270
Boiler - room	FL	40	2	2000	0.08	160	FL - 36	0.072	144	0.008	16
Children clinic	FL	40	50	3000	2	6000	FL - 36	1.8	5400	0.2	600
Children clinic	PL	13	12	3000	0.156	468	-	-	-	-	-
Cancer care building	PL	13	9	2000	0.117	234	-	-	-	-	-
Cancer care building	FL	4 x 20	57	2000	4.56	9120	FL - 4x18	4.104	8208	0.456	912
Emergency	Inc.	60	3	3500	0.18	630	CFL - 15	0.045	157.5	0.135	472
Emergency	FL	40	44	3500	1.76	6160	FL - 36	1.584	5544	0.176	616
Pharmacy	FL	40	18	3000	0.72	2160	FL - 36	0.648	1944	0.072	216
X - ray	FL	40	22	2500	0.88	2200	FL - 36	0.792	1980	0.088	220
X - ray	Inc.	60	1	2500	0.06	150	CFL - 15	0.015	37.5	0.045	112
Offices	FL	40	32	3000	1.28	3840	FL - 36	1.152	3456	0.128	384
Offices	Inc.	60	1	3000	0.06	180	CFL - 15	0.015	37.5	0.045	112

Place	Existing Conditions						Recommended Conditions			Saving	
	Type	Rating (W)	Number	Annual operating hours	Load (kW)	Consump-tion (kWh)	Replaced lamps	Load kW	Consump - tion (kWh)	Load (kW)	Consump-tion (kWh)
Administrative Corridor	FL	40	22	2500	0.88	2200	FL - 36	0.792	1980	0.088	220
Women clinic building	FL	40	62	2500	2.48	6200	FL - 36	2.232	5580	0.25	620
Lab - Internal corridor	FL	40	32	2000	1.28	2560	FL - 36	1.152	2304	0.128	256
Lab - Internal corridor	Inc.	60	4	2000	0.24	480	CFL - 15	0.06	120	0.18	360
Men clinic building	FL	40	78	2500	3.12	7800	FL - 36	2.808	7020	0.312	780
ICU	FL	40	32	3000	1.28	3840	FL - 36	1.152	3452	0.128	384
Administrative manager secre-tary office	FL	40	32	2500	1.28	3200	FL-36	1.152	2880	0.128	320
Administrative manager secre-tary office	Inc,	60	2	2500	0.12	300	CFL - 15	0.03	75	0.09	225
Total					23.593	60442		20.442	53127	3.151	7315

Energy analyzer Data at Arab Specialty Hospital (Appendix E)				
Date & Time	Pfti+ Avg	Pf1i+ Avg	Pf2i+ Avg	Pf3i+ Avg
05/11/2006 10:21	0.93	0.9	0.96	0.9
05/11/2006 10:31	0.93	0.89	0.96	0.9
05/11/2006 10:41	0.93	0.9	0.95	0.9
05/11/2006 10:51	0.93	0.9	0.95	0.9
05/11/2006 11:01	0.94	0.92	0.96	0.92
05/11/2006 11:11	0.94	0.91	0.96	0.92
05/11/2006 11:21	0.94	0.92	0.96	0.91
05/11/2006 11:31	0.93	0.9	0.96	0.9
05/11/2006 11:41	0.93	0.89	0.96	0.92
05/11/2006 11:51	0.92	0.89	0.96	0.9
05/11/2006 12:01	0.94	0.9	0.96	0.92
05/11/2006 12:11	0.94	0.91	0.96	0.93
05/11/2006 12:21	0.94	0.91	0.96	0.93
05/11/2006 12:31	0.95	0.92	0.96	0.94
05/11/2006 12:41	0.94	0.92	0.96	0.94
05/11/2006 12:51	0.94	0.92	0.96	0.94
05/11/2006 13:01	0.94	0.92	0.96	0.93
05/11/2006 13:11	0.94	0.92	0.96	0.93
05/11/2006 13:21	0.94	0.92	0.96	0.93
05/11/2006 13:31	0.94	0.93	0.97	0.93
05/11/2006 13:41	0.94	0.92	0.96	0.93
05/11/2006 13:51	0.94	0.92	0.96	0.92
05/11/2006 14:01	0.92	0.88	0.95	0.9
05/11/2006 14:11	0.92	0.88	0.95	0.9
05/11/2006 14:21	0.92	0.88	0.95	0.9
05/11/2006 14:31	0.92	0.88	0.95	0.9
05/11/2006 14:41	0.91	0.88	0.95	0.9
05/11/2006 14:51	0.93	0.9	0.96	0.9
05/11/2006 15:01	0.92	0.9	0.95	0.89
05/11/2006 15:11	0.91	0.88	0.94	0.89
05/11/2006 15:21	0.91	0.88	0.94	0.89
05/11/2006 15:31	0.91	0.88	0.94	0.89
05/11/2006 15:41	0.91	0.88	0.94	0.89
05/11/2006 15:51	0.9	0.88	0.94	0.89
05/11/2006 16:01	0.9	0.87	0.94	0.89
05/11/2006 16:11	0.9	0.87	0.93	0.9
05/11/2006 16:21	0.91	0.88	0.94	0.91
05/11/2006 16:31	0.91	0.88	0.94	0.9
05/11/2006 16:41	0.92	0.89	0.95	0.9
05/11/2006 16:51	0.93	0.92	0.95	0.89
05/11/2006 17:01	0.92	0.91	0.94	0.89
05/11/2006 17:11	0.91	0.89	0.94	0.9
05/11/2006 17:21	0.91	0.89	0.93	0.9
05/11/2006 17:31	0.91	0.9	0.94	0.9
05/11/2006 17:41	0.91	0.9	0.94	0.9
05/11/2006 17:51	0.91	0.9	0.94	0.9
05/11/2006 18:01	0.91	0.89	0.94	0.91
05/11/2006 18:11	0.91	0.88	0.94	0.9

05/11/2006 18:21	0.93	0.92	0.95	0.89
05/11/2006 18:31	0.9	0.88	0.93	0.89
05/11/2006 18:41	0.89	0.87	0.93	0.88
05/11/2006 18:51	0.9	0.88	0.93	0.89
05/11/2006 19:01	0.9	0.87	0.93	0.88
05/11/2006 19:11	0.89	0.87	0.92	0.88
05/11/2006 19:21	0.89	0.86	0.92	0.88
05/11/2006 19:31	0.89	0.87	0.93	0.88
05/11/2006 19:41	0.89	0.86	0.92	0.88
05/11/2006 19:51	0.9	0.88	0.92	0.89
05/11/2006 20:01	0.89	0.87	0.92	0.88
05/11/2006 20:11	0.89	0.88	0.92	0.86
05/11/2006 20:21	0.89	0.88	0.91	0.86
05/11/2006 20:31	0.89	0.88	0.92	0.86
05/11/2006 20:41	0.89	0.88	0.92	0.87
05/11/2006 20:51	0.89	0.88	0.92	0.87
05/11/2006 21:01	0.89	0.88	0.92	0.87
05/11/2006 21:11	0.89	0.87	0.92	0.86
05/11/2006 21:21	0.89	0.86	0.92	0.87
05/11/2006 21:31	0.88	0.87	0.91	0.87
05/11/2006 21:41	0.88	0.86	0.91	0.85
05/11/2006 21:51	0.87	0.85	0.9	0.85
05/11/2006 22:01	0.87	0.86	0.9	0.84
05/11/2006 22:11	0.88	0.86	0.92	0.85
05/11/2006 22:21	0.87	0.86	0.91	0.84
05/11/2006 22:31	0.88	0.87	0.91	0.84
05/11/2006 22:41	0.88	0.86	0.92	0.83
05/11/2006 22:51	0.88	0.88	0.9	0.83
05/11/2006 23:01	0.87	0.86	0.9	0.83
05/11/2006 23:11	0.88	0.87	0.91	0.83
05/11/2006 23:21	0.87	0.87	0.9	0.83
05/11/2006 23:31	0.87	0.88	0.9	0.83
05/11/2006 23:41	0.87	0.87	0.9	0.83
05/11/2006 23:51	0.87	0.87	0.9	0.82
06/11/2006 00:01	0.87	0.87	0.89	0.83
06/11/2006 00:11	0.88	0.88	0.9	0.85
06/11/2006 00:21	0.88	0.88	0.91	0.85
06/11/2006 00:31	0.88	0.88	0.91	0.85
06/11/2006 00:41	0.88	0.88	0.91	0.84
06/11/2006 00:51	0.88	0.87	0.92	0.83
06/11/2006 01:01	0.87	0.86	0.92	0.83
06/11/2006 01:11	0.87	0.85	0.92	0.83
06/11/2006 01:21	0.9	0.9	0.94	0.83
06/11/2006 01:31	0.88	0.87	0.92	0.83
06/11/2006 01:41	0.86	0.84	0.9	0.83
06/11/2006 01:51	0.87	0.85	0.91	0.83
06/11/2006 02:01	0.86	0.84	0.89	0.82
06/11/2006 02:11	0.84	0.84	0.87	0.8
06/11/2006 02:21	0.85	0.86	0.88	0.8
06/11/2006 02:31	0.85	0.87	0.87	0.79
06/11/2006 02:41	0.86	0.86	0.88	0.81
06/11/2006 02:51	0.85	0.86	0.88	0.8

06/11/2006 03:01	0.85	0.86	0.88	0.81
06/11/2006 03:11	0.89	0.91	0.93	0.82
06/11/2006 03:21	0.87	0.88	0.9	0.79
06/11/2006 03:31	0.84	0.85	0.87	0.77
06/11/2006 03:41	0.84	0.85	0.87	0.77
06/11/2006 03:51	0.84	0.85	0.87	0.77
06/11/2006 04:01	0.84	0.85	0.87	0.77
06/11/2006 04:11	0.84	0.84	0.89	0.77
06/11/2006 04:21	0.85	0.85	0.9	0.78
06/11/2006 04:31	0.84	0.84	0.88	0.78
06/11/2006 04:41	0.85	0.85	0.89	0.78
06/11/2006 04:51	0.85	0.84	0.89	0.78
06/11/2006 05:01	0.85	0.85	0.89	0.78
06/11/2006 05:11	0.85	0.84	0.9	0.77
06/11/2006 05:21	0.86	0.86	0.89	0.79
06/11/2006 05:31	0.86	0.86	0.9	0.79
06/11/2006 05:41	0.85	0.86	0.89	0.77
06/11/2006 05:51	0.85	0.86	0.89	0.78
06/11/2006 06:01	0.86	0.86	0.89	0.78
06/11/2006 06:11	0.87	0.88	0.9	0.8
06/11/2006 06:21	0.88	0.88	0.9	0.84
06/11/2006 06:31	0.87	0.88	0.9	0.82
06/11/2006 06:41	0.86	0.87	0.89	0.79
06/11/2006 06:51	0.9	0.89	0.93	0.85
06/11/2006 07:01	0.91	0.9	0.95	0.87
06/11/2006 07:11	0.93	0.92	0.95	0.89
06/11/2006 07:21	0.93	0.92	0.95	0.9
06/11/2006 07:31	0.94	0.94	0.96	0.91
06/11/2006 07:41	0.93	0.91	0.96	0.89
06/11/2006 07:51	0.92	0.91	0.95	0.89
06/11/2006 08:01	0.93	0.93	0.94	0.89
06/11/2006 08:11	0.92	0.91	0.94	0.88
06/11/2006 08:21	0.93	0.92	0.95	0.89
06/11/2006 08:31	0.93	0.92	0.95	0.89
06/11/2006 08:41	0.93	0.92	0.95	0.9
06/11/2006 08:51	0.93	0.91	0.95	0.89
06/11/2006 09:01	0.93	0.9	0.95	0.89
06/11/2006 09:11	0.92	0.9	0.95	0.89
06/11/2006 09:21	0.93	0.9	0.96	0.9
06/11/2006 09:31	0.93	0.91	0.96	0.91
06/11/2006 09:41	0.94	0.92	0.96	0.91
06/11/2006 09:51	0.94	0.92	0.96	0.92
06/11/2006 10:01	0.94	0.92	0.96	0.93
06/11/2006 10:11	0.93	0.91	0.95	0.92
06/11/2006 10:21	0.93	0.91	0.96	0.92
06/11/2006 10:31	0.93	0.9	0.95	0.92
06/11/2006 10:41	0.92	0.89	0.95	0.91

Energy analyzer Data at Rafidiah Hospital (Appendix F)

Date & Time	Pfti+ Avg	Pf1i+ Avg	Pf2i+ Avg	Pf3i+ Avg
27/01/2007 14:21	0.75	0.77	0.76	0.72
27/01/2007 14:31	0.75	0.78	0.76	0.71
27/01/2007 14:41	0.74	0.75	0.76	0.7
27/01/2007 14:51	0.75	0.76	0.77	0.71
27/01/2007 15:01	0.74	0.75	0.73	0.73
27/01/2007 15:11	0.73	0.74	0.74	0.72
27/01/2007 15:21	0.72	0.73	0.74	0.69
27/01/2007 15:31	0.73	0.74	0.74	0.7
27/01/2007 15:41	0.71	0.73	0.73	0.67
27/01/2007 15:51	0.73	0.74	0.73	0.7
27/01/2007 16:01	0.72	0.73	0.73	0.71
27/01/2007 16:11	0.73	0.74	0.74	0.71
27/01/2007 16:21	0.74	0.73	0.75	0.72
27/01/2007 16:31	0.74	0.74	0.75	0.72
27/01/2007 16:41	0.74	0.74	0.75	0.72
27/01/2007 16:51	0.75	0.75	0.77	0.75
27/01/2007 17:01	0.75	0.74	0.77	0.74
27/01/2007 17:11	0.76	0.76	0.78	0.74
27/01/2007 17:21	0.78	0.81	0.77	0.76
27/01/2007 17:31	0.78	0.81	0.76	0.77
27/01/2007 17:41	0.78	0.81	0.76	0.77
27/01/2007 17:51	0.78	0.81	0.77	0.77
27/01/2007 18:01	0.76	0.78	0.76	0.75
27/01/2007 18:11	0.77	0.77	0.78	0.76
27/01/2007 18:21	0.78	0.77	0.8	0.75
27/01/2007 18:31	0.78	0.78	0.8	0.76
27/01/2007 18:41	0.79	0.8	0.8	0.76
27/01/2007 18:51	0.79	0.81	0.8	0.76
27/01/2007 19:01	0.78	0.79	0.79	0.76
27/01/2007 19:11	0.77	0.81	0.75	0.76
27/01/2007 19:21	0.77	0.8	0.75	0.76
27/01/2007 19:31	0.76	0.8	0.74	0.75
27/01/2007 19:41	0.75	0.77	0.74	0.74
27/01/2007 19:51	0.76	0.78	0.75	0.76
27/01/2007 20:01	0.76	0.78	0.75	0.76
27/01/2007 20:11	0.76	0.77	0.74	0.77
27/01/2007 20:21	0.76	0.76	0.73	0.77
27/01/2007 20:31	0.76	0.76	0.75	0.77
27/01/2007 20:41	0.76	0.76	0.76	0.75
27/01/2007 20:51	0.77	0.77	0.76	0.78
27/01/2007 21:01	0.76	0.78	0.75	0.76
27/01/2007 21:11	0.76	0.77	0.74	0.76
27/01/2007 21:21	0.75	0.74	0.74	0.75
27/01/2007 21:31	0.74	0.73	0.72	0.76
27/01/2007 21:41	0.74	0.73	0.73	0.76
27/01/2007 21:51	0.75	0.74	0.73	0.77
27/01/2007 22:01	0.75	0.76	0.75	0.76
27/01/2007 22:11	0.75	0.75	0.74	0.74

27/01/2007 22:21	0.74	0.75	0.72	0.74
27/01/2007 22:31	0.74	0.75	0.71	0.75
27/01/2007 22:41	0.74	0.73	0.72	0.76
27/01/2007 22:51	0.74	0.77	0.71	0.74
27/01/2007 23:01	0.73	0.74	0.72	0.74
27/01/2007 23:11	0.75	0.74	0.73	0.77
27/01/2007 23:21	0.73	0.74	0.73	0.73
27/01/2007 23:31	0.74	0.74	0.75	0.72
27/01/2007 23:41	0.73	0.74	0.73	0.71
27/01/2007 23:51	0.72	0.72	0.73	0.7
28/01/2007 00:01	0.74	0.73	0.75	0.73
28/01/2007 00:11	0.73	0.73	0.75	0.73
28/01/2007 00:21	0.73	0.72	0.74	0.73
28/01/2007 00:31	0.73	0.72	0.76	0.72
28/01/2007 00:41	0.74	0.73	0.76	0.73
28/01/2007 00:51	0.73	0.72	0.76	0.7
28/01/2007 01:01	0.72	0.71	0.74	0.71
28/01/2007 01:11	0.72	0.72	0.75	0.7
28/01/2007 01:21	0.72	0.72	0.77	0.68
28/01/2007 01:31	0.72	0.71	0.79	0.66
28/01/2007 01:41	0.72	0.71	0.79	0.66
28/01/2007 01:51	0.72	0.71	0.79	0.66
28/01/2007 02:01	0.73	0.72	0.78	0.7
28/01/2007 02:11	0.73	0.71	0.78	0.7
28/01/2007 02:21	0.72	0.7	0.76	0.71
28/01/2007 02:31	0.71	0.71	0.71	0.71
28/01/2007 02:41	0.7	0.7	0.7	0.69
28/01/2007 02:51	0.7	0.7	0.7	0.69
28/01/2007 03:01	0.7	0.7	0.7	0.69
28/01/2007 03:11	0.7	0.7	0.71	0.69
28/01/2007 03:21	0.7	0.71	0.71	0.69
28/01/2007 03:31	0.71	0.71	0.71	0.7
28/01/2007 03:41	0.71	0.71	0.72	0.7
28/01/2007 03:51	0.71	0.7	0.71	0.7
28/01/2007 04:01	0.71	0.7	0.71	0.71
28/01/2007 04:11	0.71	0.7	0.72	0.71
28/01/2007 04:21	0.71	0.71	0.71	0.72
28/01/2007 04:31	0.71	0.71	0.71	0.71
28/01/2007 04:41	0.71	0.71	0.72	0.71
28/01/2007 04:51	0.72	0.71	0.73	0.71
28/01/2007 05:01	0.72	0.72	0.73	0.71
28/01/2007 05:11	0.72	0.72	0.73	0.7
28/01/2007 05:21	0.71	0.72	0.72	0.71
28/01/2007 05:31	0.72	0.72	0.72	0.71
28/01/2007 05:41	0.72	0.72	0.74	0.71
28/01/2007 05:51	0.73	0.74	0.74	0.71
28/01/2007 06:01	0.73	0.73	0.74	0.71
28/01/2007 06:11	0.74	0.74	0.77	0.71
28/01/2007 06:21	0.72	0.74	0.74	0.68
28/01/2007 06:31	0.73	0.72	0.76	0.69
28/01/2007 06:41	0.75	0.76	0.76	0.72
28/01/2007 06:51	0.76	0.78	0.78	0.73

28/01/2007 07:01	0.77	0.78	0.76	0.76
28/01/2007 07:11	0.78	0.79	0.77	0.78
28/01/2007 07:21	0.77	0.73	0.77	0.78
28/01/2007 07:31	0.78	0.76	0.8	0.77
28/01/2007 07:41	0.78	0.76	0.81	0.76
28/01/2007 07:51	0.79	0.77	0.82	0.76
28/01/2007 08:01	0.79	0.8	0.8	0.78
28/01/2007 08:11	0.8	0.8	0.82	0.77
28/01/2007 08:21	0.79	0.8	0.81	0.76
28/01/2007 08:31	0.79	0.79	0.8	0.77
28/01/2007 08:41	0.79	0.8	0.81	0.74
28/01/2007 08:51	0.8	0.8	0.83	0.76
28/01/2007 09:01	0.8	0.82	0.83	0.76
28/01/2007 09:11	0.8	0.8	0.83	0.76
28/01/2007 09:21	0.79	0.8	0.81	0.76
28/01/2007 09:31	0.79	0.81	0.81	0.75
28/01/2007 09:41	0.8	0.84	0.81	0.76
28/01/2007 09:51	0.81	0.83	0.83	0.77
28/01/2007 10:01	0.81	0.84	0.82	0.78
28/01/2007 10:11	0.81	0.84	0.82	0.77
28/01/2007 10:21	0.81	0.83	0.81	0.78
28/01/2007 10:31	0.8	0.83	0.8	0.77
28/01/2007 10:41	0.81	0.83	0.81	0.8
28/01/2007 10:51	0.82	0.83	0.82	0.81
28/01/2007 11:01	0.8	0.81	0.81	0.77
28/01/2007 11:11	0.8	0.8	0.81	0.77
28/01/2007 11:21	0.81	0.81	0.82	0.78
28/01/2007 11:31	0.79	0.79	0.81	0.78
28/01/2007 11:41	0.78	0.76	0.8	0.77
28/01/2007 11:51	0.77	0.76	0.8	0.75
28/01/2007 12:01	0.78	0.79	0.8	0.75
28/01/2007 12:11	0.77	0.77	0.8	0.73
28/01/2007 12:21	0.76	0.76	0.8	0.72
28/01/2007 12:31	0.77	0.78	0.8	0.71
28/01/2007 12:41	0.77	0.78	0.81	0.72
28/01/2007 12:51	0.77	0.77	0.8	0.72
28/01/2007 13:01	0.76	0.76	0.8	0.71
28/01/2007 13:11	0.76	0.75	0.8	0.71
28/01/2007 13:21	0.77	0.76	0.8	0.74
28/01/2007 13:31	0.77	0.77	0.8	0.73
28/01/2007 13:41	0.77	0.76	0.8	0.74
28/01/2007 13:51	0.76	0.76	0.79	0.73
28/01/2007 14:01	0.75	0.75	0.78	0.71
28/01/2007 14:11	0.75	0.77	0.78	0.7
28/01/2007 14:21	0.74	0.76	0.77	0.69
28/01/2007 14:31	0.74	0.75	0.77	0.69
28/01/2007 14:41	0.74	0.74	0.76	0.69
28/01/2007 14:51	0.74	0.74	0.76	0.7
28/01/2007 15:01	0.73	0.73	0.74	0.72
28/01/2007 15:11	0.73	0.74	0.72	0.71
28/01/2007 15:21	0.72	0.75	0.73	0.68
28/01/2007 15:31	0.71	0.72	0.73	0.68

28/01/2007 15:41	0.71	0.72	0.73	0.67
28/01/2007 15:51	0.73	0.74	0.75	0.71
28/01/2007 16:01	0.73	0.74	0.75	0.69
28/01/2007 16:11	0.74	0.75	0.78	0.7
28/01/2007 16:21	0.75	0.75	0.78	0.7
28/01/2007 16:31	0.77	0.77	0.78	0.76
28/01/2007 16:41	0.78	0.78	0.78	0.76
28/01/2007 16:51	0.77	0.77	0.79	0.75
28/01/2007 17:01	0.79	0.81	0.8	0.77
28/01/2007 17:11	0.79	0.8	0.79	0.79
28/01/2007 17:21	0.78	0.78	0.78	0.77
28/01/2007 17:31	0.79	0.79	0.78	0.8
28/01/2007 17:41	0.78	0.79	0.78	0.79
28/01/2007 17:51	0.78	0.78	0.77	0.78
28/01/2007 18:01	0.78	0.79	0.77	0.77
28/01/2007 18:11	0.78	0.79	0.79	0.76
28/01/2007 18:21	0.78	0.78	0.78	0.77
28/01/2007 18:31	0.78	0.79	0.77	0.77
28/01/2007 18:41	0.78	0.8	0.77	0.77
28/01/2007 18:51	0.76	0.79	0.76	0.75
28/01/2007 19:01	0.77	0.79	0.77	0.75
28/01/2007 19:11	0.77	0.79	0.76	0.75
28/01/2007 19:21	0.78	0.79	0.76	0.79
28/01/2007 19:31	0.77	0.79	0.75	0.77
28/01/2007 19:41	0.77	0.77	0.76	0.77
28/01/2007 19:51	0.77	0.79	0.75	0.77
28/01/2007 20:01	0.76	0.77	0.75	0.76
28/01/2007 20:11	0.76	0.77	0.75	0.77
28/01/2007 20:21	0.76	0.77	0.74	0.78
28/01/2007 20:31	0.77	0.79	0.75	0.78
28/01/2007 20:41	0.77	0.78	0.75	0.79
28/01/2007 20:51	0.77	0.78	0.75	0.79
28/01/2007 21:01	0.77	0.79	0.73	0.78
28/01/2007 21:11	0.77	0.78	0.73	0.79
28/01/2007 21:21	0.77	0.78	0.76	0.79
28/01/2007 21:31	0.78	0.78	0.77	0.8
28/01/2007 21:41	0.78	0.78	0.77	0.79
28/01/2007 21:51	0.77	0.77	0.76	0.79
28/01/2007 22:01	0.77	0.76	0.76	0.79
28/01/2007 22:11	0.78	0.78	0.76	0.81
28/01/2007 22:21	0.78	0.77	0.75	0.82
28/01/2007 22:31	0.8	0.78	0.79	0.83
28/01/2007 22:41	0.79	0.76	0.78	0.82
28/01/2007 22:51	0.78	0.75	0.78	0.81
28/01/2007 23:01	0.78	0.75	0.77	0.81
28/01/2007 23:11	0.79	0.77	0.77	0.81
28/01/2007 23:21	0.79	0.77	0.76	0.83
28/01/2007 23:31	0.78	0.77	0.76	0.81
28/01/2007 23:41	0.78	0.77	0.76	0.8
28/01/2007 23:51	0.78	0.75	0.75	0.81
29/01/2007 00:01	0.78	0.76	0.75	0.82
29/01/2007 00:11	0.78	0.75	0.74	0.83

29/01/2007 00:21	0.78	0.76	0.74	0.82
29/01/2007 00:31	0.78	0.76	0.74	0.83
29/01/2007 00:41	0.78	0.75	0.75	0.83
29/01/2007 00:51	0.78	0.74	0.77	0.83
29/01/2007 01:01	0.77	0.75	0.74	0.82
29/01/2007 01:11	0.77	0.74	0.75	0.81
29/01/2007 01:21	0.77	0.74	0.74	0.81
29/01/2007 01:31	0.77	0.75	0.74	0.8
29/01/2007 01:41	0.77	0.75	0.76	0.8
29/01/2007 01:51	0.77	0.74	0.76	0.8
29/01/2007 02:01	0.77	0.74	0.76	0.8
29/01/2007 02:11	0.76	0.74	0.75	0.8
29/01/2007 02:21	0.77	0.75	0.77	0.8
29/01/2007 02:31	0.77	0.75	0.77	0.78
29/01/2007 02:41	0.77	0.76	0.78	0.78
29/01/2007 02:51	0.77	0.75	0.77	0.78
29/01/2007 03:01	0.77	0.75	0.77	0.8
29/01/2007 03:11	0.77	0.75	0.76	0.8
29/01/2007 03:21	0.77	0.75	0.76	0.79
29/01/2007 03:31	0.76	0.75	0.76	0.79
29/01/2007 03:41	0.76	0.74	0.75	0.78
29/01/2007 03:51	0.76	0.74	0.75	0.77
29/01/2007 04:01	0.76	0.74	0.75	0.77
29/01/2007 04:11	0.76	0.74	0.76	0.78
29/01/2007 04:21	0.76	0.73	0.75	0.79
29/01/2007 04:31	0.76	0.73	0.75	0.8
29/01/2007 04:41	0.77	0.73	0.76	0.81
29/01/2007 04:51	0.77	0.74	0.76	0.8
29/01/2007 05:01	0.78	0.76	0.77	0.81
29/01/2007 05:11	0.78	0.75	0.77	0.82
29/01/2007 05:21	0.78	0.75	0.76	0.81
29/01/2007 05:31	0.78	0.75	0.77	0.82
29/01/2007 05:41	0.78	0.75	0.76	0.82
29/01/2007 05:51	0.77	0.75	0.72	0.81
29/01/2007 06:01	0.77	0.76	0.73	0.81
29/01/2007 06:11	0.78	0.74	0.76	0.82
29/01/2007 06:21	0.78	0.77	0.76	0.81
29/01/2007 06:31	0.79	0.78	0.76	0.81
29/01/2007 06:41	0.79	0.78	0.77	0.82
29/01/2007 06:51	0.79	0.78	0.77	0.81
29/01/2007 07:01	0.8	0.78	0.82	0.81
29/01/2007 07:11	0.79	0.75	0.79	0.82
29/01/2007 07:21	0.79	0.76	0.78	0.83
29/01/2007 07:31	0.81	0.79	0.81	0.82
29/01/2007 07:41	0.82	0.8	0.82	0.82
29/01/2007 07:51	0.82	0.8	0.85	0.82
29/01/2007 08:01	0.82	0.8	0.83	0.82
29/01/2007 08:11	0.83	0.81	0.82	0.85
29/01/2007 08:21	0.83	0.82	0.83	0.83
29/01/2007 08:31	0.83	0.83	0.83	0.82
29/01/2007 08:41	0.83	0.86	0.82	0.83
29/01/2007 08:51	0.84	0.86	0.83	0.84

29/01/2007 09:01	0.84	0.86	0.82	0.84
29/01/2007 09:11	0.84	0.86	0.83	0.84
29/01/2007 09:21	0.85	0.88	0.83	0.83
29/01/2007 09:31	0.84	0.87	0.83	0.82
29/01/2007 09:41	0.84	0.86	0.84	0.84
29/01/2007 09:51	0.84	0.84	0.84	0.85
29/01/2007 10:01	0.85	0.86	0.85	0.83
29/01/2007 10:11	0.85	0.86	0.85	0.84
29/01/2007 10:21	0.84	0.84	0.85	0.83
29/01/2007 10:31	0.85	0.85	0.85	0.85
29/01/2007 10:41	0.85	0.86	0.85	0.85
29/01/2007 10:51	0.85	0.86	0.84	0.83
29/01/2007 11:01	0.86	0.88	0.85	0.84
29/01/2007 11:11	0.85	0.86	0.85	0.85
29/01/2007 11:21	0.85	0.86	0.85	0.85
29/01/2007 11:31	0.85	0.88	0.84	0.84
29/01/2007 11:41	0.85	0.87	0.85	0.83
29/01/2007 11:51	0.85	0.87	0.84	0.84
29/01/2007 12:01	0.84	0.86	0.84	0.81
29/01/2007 12:11	0.84	0.86	0.85	0.81
29/01/2007 12:21	0.84	0.87	0.84	0.81
29/01/2007 12:31	0.85	0.88	0.84	0.82
29/01/2007 12:41	0.85	0.88	0.85	0.81
29/01/2007 12:51	0.86	0.88	0.86	0.82
29/01/2007 13:01	0.85	0.88	0.86	0.81
29/01/2007 13:11	0.85	0.86	0.86	0.81
29/01/2007 13:21	0.85	0.88	0.86	0.81
29/01/2007 13:31	0.86	0.89	0.86	0.81
29/01/2007 13:41	0.86	0.89	0.85	0.83
29/01/2007 13:51	0.85	0.88	0.84	0.81
29/01/2007 14:01	0.83	0.87	0.82	0.81
29/01/2007 14:11	0.84	0.88	0.83	0.82
29/01/2007 14:21	0.83	0.87	0.81	0.82
29/01/2007 14:31	0.82	0.85	0.81	0.81
29/01/2007 14:41	0.81	0.84	0.8	0.79
29/01/2007 14:51	0.78	0.8	0.77	0.76
29/01/2007 15:01	0.77	0.8	0.76	0.75
29/01/2007 15:11	0.78	0.8	0.77	0.76
29/01/2007 15:21	0.79	0.81	0.77	0.78
29/01/2007 15:31	0.79	0.81	0.76	0.79
29/01/2007 15:41	0.78	0.82	0.76	0.75
29/01/2007 15:51	0.78	0.8	0.77	0.77
29/01/2007 16:01	0.78	0.79	0.77	0.77
29/01/2007 16:11	0.78	0.77	0.78	0.78
29/01/2007 16:21	0.79	0.79	0.79	0.78
29/01/2007 16:31	0.8	0.78	0.8	0.81
29/01/2007 16:41	0.81	0.79	0.8	0.82
29/01/2007 16:51	0.8	0.79	0.79	0.81
29/01/2007 17:01	0.81	0.81	0.79	0.83
29/01/2007 17:11	0.81	0.81	0.79	0.82
29/01/2007 17:21	0.81	0.81	0.8	0.81
29/01/2007 17:31	0.8	0.82	0.79	0.8

29/01/2007 17:41	0.8	0.82	0.79	0.79
29/01/2007 17:51	0.8	0.81	0.79	0.79
29/01/2007 18:01	0.81	0.81	0.8	0.81
29/01/2007 18:11	0.81	0.81	0.79	0.83
29/01/2007 18:21	0.81	0.8	0.79	0.84
29/01/2007 18:31	0.81	0.81	0.79	0.84
29/01/2007 18:41	0.82	0.82	0.8	0.84
29/01/2007 18:51	0.81	0.81	0.8	0.84
29/01/2007 19:01	0.81	0.8	0.79	0.84
29/01/2007 19:11	0.81	0.79	0.79	0.83
29/01/2007 19:21	0.81	0.81	0.79	0.82
29/01/2007 19:31	0.79	0.8	0.78	0.8
29/01/2007 19:41	0.8	0.82	0.78	0.8
29/01/2007 19:51	0.8	0.82	0.78	0.8
29/01/2007 20:01	0.8	0.81	0.78	0.8
29/01/2007 20:11	0.79	0.81	0.77	0.79
29/01/2007 20:21	0.79	0.8	0.77	0.79
29/01/2007 20:31	0.78	0.79	0.76	0.79
29/01/2007 20:41	0.79	0.8	0.77	0.79
29/01/2007 20:51	0.8	0.82	0.77	0.8
29/01/2007 21:01	0.79	0.81	0.77	0.8
29/01/2007 21:11	0.8	0.81	0.79	0.8
29/01/2007 21:21	0.8	0.81	0.78	0.81
29/01/2007 21:31	0.8	0.81	0.78	0.81
29/01/2007 21:41	0.8	0.82	0.78	0.81
29/01/2007 21:51	0.8	0.82	0.78	0.81
29/01/2007 22:01	0.8	0.82	0.77	0.81
29/01/2007 22:11	0.8	0.81	0.75	0.82
29/01/2007 22:21	0.8	0.81	0.75	0.83
29/01/2007 22:31	0.8	0.81	0.76	0.82
29/01/2007 22:41	0.79	0.82	0.74	0.81
29/01/2007 22:51	0.79	0.82	0.73	0.81
29/01/2007 23:01	0.79	0.81	0.75	0.8
29/01/2007 23:11	0.78	0.8	0.74	0.79
29/01/2007 23:21	0.78	0.79	0.74	0.8
29/01/2007 23:31	0.79	0.81	0.74	0.8
29/01/2007 23:41	0.79	0.8	0.75	0.81
29/01/2007 23:51	0.78	0.78	0.74	0.81
30/01/2007 00:01	0.79	0.78	0.74	0.82
30/01/2007 00:11	0.78	0.79	0.73	0.8
30/01/2007 00:21	0.77	0.78	0.73	0.8
30/01/2007 00:31	0.77	0.78	0.74	0.79
30/01/2007 00:41	0.79	0.78	0.77	0.81
30/01/2007 00:51	0.79	0.79	0.76	0.81
30/01/2007 01:01	0.78	0.78	0.76	0.79
30/01/2007 01:11	0.78	0.78	0.75	0.79
30/01/2007 01:21	0.78	0.78	0.76	0.79
30/01/2007 01:31	0.77	0.77	0.75	0.78
30/01/2007 01:41	0.77	0.77	0.74	0.78
30/01/2007 01:51	0.77	0.77	0.75	0.79
30/01/2007 02:01	0.78	0.77	0.75	0.8
30/01/2007 02:11	0.77	0.78	0.74	0.79

30/01/2007 02:21	0.77	0.77	0.74	0.79
30/01/2007 02:31	0.78	0.77	0.75	0.8
30/01/2007 02:41	0.78	0.77	0.74	0.8
30/01/2007 02:51	0.78	0.78	0.75	0.8
30/01/2007 03:01	0.78	0.78	0.75	0.8
30/01/2007 03:11	0.78	0.77	0.75	0.81
30/01/2007 03:21	0.77	0.78	0.74	0.8
30/01/2007 03:31	0.78	0.77	0.76	0.8
30/01/2007 03:41	0.77	0.77	0.75	0.8
30/01/2007 03:51	0.77	0.77	0.74	0.8
30/01/2007 04:01	0.77	0.78	0.74	0.79
30/01/2007 04:11	0.77	0.78	0.74	0.79
30/01/2007 04:21	0.77	0.78	0.74	0.79
30/01/2007 04:31	0.77	0.78	0.74	0.79
30/01/2007 04:41	0.79	0.8	0.75	0.8
30/01/2007 04:51	0.79	0.79	0.77	0.8
30/01/2007 05:01	0.79	0.8	0.76	0.8
30/01/2007 05:11	0.79	0.8	0.75	0.8
30/01/2007 05:21	0.79	0.8	0.77	0.8
30/01/2007 05:31	0.79	0.8	0.78	0.8
30/01/2007 05:41	0.8	0.81	0.79	0.78
30/01/2007 05:51	0.79	0.81	0.78	0.79
30/01/2007 06:01	0.8	0.82	0.76	0.79
30/01/2007 06:11	0.78	0.81	0.77	0.78
30/01/2007 06:21	0.76	0.77	0.75	0.77
30/01/2007 06:31	0.77	0.78	0.75	0.76
30/01/2007 06:41	0.77	0.75	0.76	0.78
30/01/2007 06:51	0.78	0.77	0.78	0.78
30/01/2007 07:01	0.79	0.8	0.79	0.77
30/01/2007 07:11	0.79	0.79	0.8	0.78
30/01/2007 07:21	0.81	0.8	0.81	0.81
30/01/2007 07:31	0.82	0.82	0.8	0.82
30/01/2007 07:41	0.82	0.82	0.81	0.82
30/01/2007 07:51	0.82	0.83	0.81	0.81
30/01/2007 08:01	0.82	0.82	0.82	0.81
30/01/2007 08:11	0.82	0.83	0.83	0.8
30/01/2007 08:21	0.82	0.84	0.83	0.8
30/01/2007 08:31	0.82	0.84	0.82	0.81
30/01/2007 08:41	0.84	0.88	0.83	0.82
30/01/2007 08:51	0.85	0.89	0.85	0.82
30/01/2007 09:01	0.84	0.87	0.85	0.82
30/01/2007 09:11	0.84	0.87	0.84	0.81
30/01/2007 09:21	0.85	0.89	0.83	0.82
30/01/2007 09:31	0.83	0.87	0.83	0.8
30/01/2007 09:41	0.83	0.87	0.83	0.81
30/01/2007 09:51	0.85	0.88	0.84	0.83
30/01/2007 10:01	0.85	0.88	0.84	0.83
30/01/2007 10:11	0.85	0.88	0.85	0.83
30/01/2007 10:21	0.85	0.87	0.84	0.82
30/01/2007 10:31	0.85	0.87	0.84	0.82
30/01/2007 10:41	0.85	0.87	0.85	0.82
30/01/2007 10:51	0.86	0.88	0.86	0.83

Energy analyzer Data at Ittihad Hospital (Appendix G)

Date & Time	Pfti+ Avg	Pf1i+ Avg	Pf2i+ Avg	Pf3i+ Avg
18/03/2007 12:25	0.93	0.92	0.91	0.95
18/03/2007 13:25	0.92	0.9	0.92	0.93
18/03/2007 14:25	0.92	0.92	0.92	0.92
18/03/2007 15:25	0.93	0.91	0.93	0.93
18/03/2007 16:25	0.93	0.93	0.93	0.93
18/03/2007 17:25	0.93	0.93	0.94	0.93
18/03/2007 18:25	0.94	0.94	0.94	0.94
18/03/2007 19:25	0.94	0.94	0.94	0.93
18/03/2007 20:25	0.94	0.94	0.95	0.93
18/03/2007 21:25	0.94	0.95	0.95	0.93
18/03/2007 22:25	0.95	0.95	0.96	0.93
18/03/2007 23:25	0.95	0.95	0.96	0.93
19/03/2007 00:25	0.94	0.94	0.96	0.92
19/03/2007 01:25	0.94	0.94	0.96	0.93
19/03/2007 02:25	0.95	0.94	0.96	0.93
19/03/2007 03:25	0.96	0.96	0.97	0.94
19/03/2007 04:25	0.96	0.96	0.97	0.95
19/03/2007 05:25	0.95	0.95	0.96	0.95
19/03/2007 06:25	0.93	0.92	0.93	0.93
19/03/2007 07:25	0.92	0.92	0.91	0.92
19/03/2007 08:25	0.93	0.92	0.91	0.95
19/03/2007 09:25	0.93	0.93	0.91	0.95
19/03/2007 10:25	0.92	0.9	0.92	0.94
19/03/2007 11:25	0.93	0.91	0.91	0.95
19/03/2007 12:25	0.93	0.91	0.92	0.95
19/03/2007 13:25	0.92	0.92	0.9	0.93
19/03/2007 14:25	0.92	0.91	0.92	0.93
19/03/2007 15:25	0.93	0.92	0.94	0.92
19/03/2007 16:25	0.92	0.91	0.93	0.91
19/03/2007 17:25	0.93	0.91	0.94	0.92
19/03/2007 18:25	0.93	0.92	0.93	0.92
19/03/2007 19:25	0.93	0.93	0.93	0.93
19/03/2007 20:25	0.93	0.93	0.94	0.93
19/03/2007 21:25	0.94	0.93	0.94	0.93
19/03/2007 22:25	0.93	0.93	0.93	0.93
19/03/2007 23:25	0.93	0.93	0.92	0.94
20/03/2007 00:25	0.93	0.93	0.92	0.93
20/03/2007 01:25	0.92	0.92	0.91	0.93
20/03/2007 02:25	0.91	0.92	0.91	0.92
20/03/2007 03:25	0.91	0.91	0.92	0.91
20/03/2007 04:25	0.92	0.92	0.92	0.92
20/03/2007 05:25	0.92	0.91	0.91	0.93
20/03/2007 06:25	0.89	0.87	0.89	0.9
20/03/2007 07:25	0.89	0.89	0.89	0.89
20/03/2007 08:25	0.91	0.91	0.9	0.93
20/03/2007 09:25	0.91	0.9	0.89	0.94
20/03/2007 10:25	0.92	0.92	0.9	0.94
20/03/2007 11:25	0.93	0.92	0.9	0.95

20/03/2007 12:25	0.93	0.92	0.93	0.94
20/03/2007 13:25	0.91	0.89	0.91	0.93
20/03/2007 14:25	0.9	0.87	0.91	0.92
20/03/2007 15:25	0.91	0.88	0.93	0.9
20/03/2007 16:25	0.91	0.88	0.93	0.91
20/03/2007 17:25	0.92	0.9	0.92	0.92
20/03/2007 18:25	0.93	0.93	0.92	0.93
20/03/2007 19:25	0.93	0.93	0.92	0.94
20/03/2007 20:25	0.92	0.93	0.91	0.93
20/03/2007 21:25	0.94	0.94	0.93	0.95
20/03/2007 22:25	0.94	0.94	0.93	0.94
20/03/2007 23:25	0.94	0.94	0.93	0.94
21/03/2007 00:25	0.93	0.93	0.92	0.94
21/03/2007 01:25	0.92	0.92	0.91	0.94
21/03/2007 02:25	0.92	0.92	0.9	0.94
21/03/2007 03:25	0.92	0.92	0.9	0.94
21/03/2007 04:25	0.93	0.93	0.92	0.95
21/03/2007 05:25	0.94	0.94	0.92	0.95
21/03/2007 06:25	0.9	0.91	0.88	0.93
21/03/2007 07:25	0.89	0.89	0.89	0.9
21/03/2007 08:25	0.91	0.91	0.9	0.91
21/03/2007 09:25	0.92	0.91	0.91	0.92
21/03/2007 10:25	0.92	0.91	0.91	0.94
21/03/2007 11:25	0.93	0.92	0.93	0.94

Energy analyzer Data at Watani Hospital (Appendix H)

Date & Time	Pfti+ Avg	Pf1i+ Avg	Pf2i+ Avg	Pf3i+ Avg
11/03/2007 10:58	0.88	0.86	0.92	0.88
11/03/2007 11:08	0.88	0.87	0.92	0.87
11/03/2007 11:18	0.88	0.86	0.92	0.87
11/03/2007 11:28	0.89	0.87	0.92	0.87
11/03/2007 11:38	0.9	0.89	0.94	0.89
11/03/2007 11:48	0.88	0.86	0.91	0.87
11/03/2007 11:58	0.88	0.87	0.92	0.86
11/03/2007 12:08	0.9	0.88	0.94	0.87
11/03/2007 12:18	0.9	0.88	0.93	0.87
11/03/2007 12:28	0.9	0.88	0.94	0.88
11/03/2007 12:38	0.89	0.86	0.94	0.88
11/03/2007 12:48	0.87	0.83	0.93	0.86
11/03/2007 12:58	0.88	0.83	0.94	0.85
11/03/2007 13:08	0.87	0.81	0.92	0.85
11/03/2007 13:18	0.88	0.84	0.93	0.88
11/03/2007 13:28	0.89	0.84	0.93	0.89
11/03/2007 13:38	0.89	0.84	0.93	0.89
11/03/2007 13:48	0.89	0.86	0.93	0.87
11/03/2007 13:58	0.89	0.86	0.92	0.89
11/03/2007 14:08	0.89	0.87	0.92	0.89
11/03/2007 14:18	0.89	0.87	0.92	0.89
11/03/2007 14:28	0.9	0.88	0.93	0.89
11/03/2007 14:38	0.89	0.87	0.92	0.88
11/03/2007 14:48	0.89	0.87	0.92	0.89
11/03/2007 14:58	0.87	0.81	0.91	0.88
11/03/2007 15:08	0.88	0.83	0.92	0.89
11/03/2007 15:18	0.91	0.87	0.94	0.91
11/03/2007 15:28	0.91	0.87	0.94	0.9
11/03/2007 15:38	0.9	0.87	0.94	0.89
11/03/2007 15:48	0.92	0.88	0.95	0.91
11/03/2007 15:58	0.92	0.89	0.95	0.93
11/03/2007 16:08	0.91	0.84	0.94	0.93
11/03/2007 16:18	0.92	0.89	0.95	0.92
11/03/2007 16:28	0.9	0.86	0.94	0.89
11/03/2007 16:38	0.89	0.87	0.92	0.89
11/03/2007 16:48	0.9	0.88	0.93	0.91
11/03/2007 16:58	0.91	0.9	0.93	0.9
11/03/2007 17:08	0.9	0.88	0.91	0.92
11/03/2007 17:18	0.9	0.88	0.91	0.92
11/03/2007 17:28	0.91	0.9	0.89	0.93
11/03/2007 17:38	0.91	0.91	0.89	0.93
11/03/2007 17:48	0.91	0.91	0.88	0.93
11/03/2007 17:58	0.9	0.9	0.89	0.92
11/03/2007 18:08	0.92	0.9	0.91	0.94
11/03/2007 18:18	0.93	0.91	0.92	0.95
11/03/2007 18:28	0.92	0.9	0.92	0.95
11/03/2007 18:38	0.92	0.89	0.92	0.95

11/03/2007 18:48	0.93	0.9	0.93	0.95
11/03/2007 18:58	0.91	0.88	0.92	0.94
11/03/2007 19:08	0.91	0.88	0.9	0.93
11/03/2007 19:18	0.91	0.89	0.9	0.93
11/03/2007 19:28	0.91	0.89	0.9	0.93
11/03/2007 19:38	0.89	0.87	0.88	0.92
11/03/2007 19:48	0.89	0.88	0.87	0.92
11/03/2007 19:58	0.91	0.89	0.9	0.94
11/03/2007 20:08	0.91	0.88	0.9	0.93
11/03/2007 20:18	0.91	0.92	0.89	0.93
11/03/2007 20:28	0.89	0.88	0.87	0.91
11/03/2007 20:38	0.89	0.87	0.89	0.92
11/03/2007 20:48	0.88	0.84	0.88	0.91
11/03/2007 20:58	0.88	0.86	0.88	0.91
11/03/2007 21:08	0.9	0.87	0.89	0.92
11/03/2007 21:18	0.88	0.82	0.88	0.92
11/03/2007 21:28	0.88	0.85	0.88	0.91
11/03/2007 21:38	0.88	0.83	0.88	0.92
11/03/2007 21:48	0.89	0.85	0.88	0.94
11/03/2007 21:58	0.89	0.87	0.85	0.94
11/03/2007 22:08	0.91	0.85	0.88	0.97
11/03/2007 22:18	0.91	0.87	0.88	0.96
11/03/2007 22:28	0.9	0.89	0.84	0.94
11/03/2007 22:38	0.88	0.86	0.83	0.93
11/03/2007 22:48	0.88	0.86	0.84	0.93
11/03/2007 22:58	0.89	0.88	0.83	0.94
11/03/2007 23:08	0.9	0.89	0.84	0.94
11/03/2007 23:18	0.91	0.9	0.86	0.94
11/03/2007 23:28	0.9	0.87	0.87	0.95
11/03/2007 23:38	0.91	0.87	0.88	0.97
11/03/2007 23:48	0.92	0.89	0.9	0.96
11/03/2007 23:58	0.94	0.93	0.93	0.97
12/03/2007 00:08	0.94	0.91	0.93	0.98
12/03/2007 00:18	0.94	0.88	0.94	0.98
12/03/2007 00:28	0.95	0.91	0.95	0.98
12/03/2007 00:38	0.95	0.9	0.96	0.98
12/03/2007 00:48	0.95	0.89	0.97	0.98
12/03/2007 00:58	0.96	0.91	0.98	0.99
12/03/2007 01:08	0.96	0.89	0.98	0.98
12/03/2007 01:18	0.96	0.9	0.98	0.99
12/03/2007 01:28	0.95	0.83	0.98	0.99
12/03/2007 01:38	0.96	0.9	0.97	0.98
12/03/2007 01:48	0.95	0.86	0.98	0.99
12/03/2007 01:58	0.96	0.88	0.98	0.99
12/03/2007 02:08	0.96	0.84	0.98	0.99
12/03/2007 02:18	0.96	0.87	0.98	0.98
12/03/2007 02:28	0.97	0.86	0.98	0.99
12/03/2007 02:38	0.96	0.9	0.98	0.99
12/03/2007 02:48	0.97	0.93	0.98	0.98
12/03/2007 02:58	0.97	0.93	0.98	0.98
12/03/2007 03:08	0.96	0.92	0.97	0.98
12/03/2007 03:18	0.96	0.89	0.97	0.99

12/03/2007 03:28	0.96	0.91	0.96	0.98
12/03/2007 03:38	0.96	0.9	0.97	0.99
12/03/2007 03:48	0.96	0.92	0.98	0.98
12/03/2007 03:58	0.97	0.93	0.97	0.99
12/03/2007 04:08	0.96	0.88	0.97	0.99
12/03/2007 04:18	0.96	0.85	0.97	0.99
12/03/2007 04:28	0.97	0.89	0.98	0.99
12/03/2007 04:38	0.96	0.92	0.97	0.99
12/03/2007 04:48	0.96	0.92	0.96	0.98
12/03/2007 04:58	0.95	0.89	0.97	0.96
12/03/2007 05:08	0.95	0.88	0.97	0.98
12/03/2007 05:18	0.95	0.9	0.96	0.97
12/03/2007 05:28	0.95	0.92	0.95	0.97
12/03/2007 05:38	0.93	0.89	0.93	0.96
12/03/2007 05:48	0.93	0.9	0.93	0.97
12/03/2007 05:58	0.93	0.91	0.91	0.96
12/03/2007 06:08	0.92	0.91	0.89	0.95
12/03/2007 06:18	0.92	0.91	0.9	0.94
12/03/2007 06:28	0.93	0.91	0.92	0.95
12/03/2007 06:38	0.92	0.9	0.91	0.94
12/03/2007 06:48	0.93	0.9	0.93	0.95
12/03/2007 06:58	0.94	0.92	0.95	0.95
12/03/2007 07:08	0.94	0.92	0.95	0.94
12/03/2007 07:18	0.94	0.92	0.95	0.94
12/03/2007 07:28	0.94	0.94	0.96	0.93
12/03/2007 07:38	0.94	0.93	0.96	0.93
12/03/2007 07:48	0.92	0.92	0.94	0.91
12/03/2007 07:58	0.92	0.9	0.94	0.91
12/03/2007 08:08	0.92	0.91	0.94	0.9
12/03/2007 08:18	0.92	0.92	0.95	0.88
12/03/2007 08:28	0.92	0.92	0.94	0.89
12/03/2007 08:38	0.93	0.91	0.97	0.89
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12/03/2007 08:58	0.93	0.91	0.97	0.9
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12/03/2007 09:18	0.94	0.93	0.97	0.9
12/03/2007 09:28	0.94	0.94	0.97	0.89
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12/03/2007 09:48	0.93	0.92	0.96	0.9
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12/03/2007 10:18	0.93	0.92	0.96	0.9
12/03/2007 10:28	0.92	0.9	0.96	0.89
12/03/2007 10:38	0.93	0.92	0.97	0.9
12/03/2007 10:48	0.93	0.93	0.97	0.9
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12/03/2007 11:08	0.92	0.91	0.95	0.89
12/03/2007 11:18	0.92	0.9	0.95	0.9
12/03/2007 11:28	0.92	0.89	0.96	0.91
12/03/2007 11:38	0.93	0.9	0.96	0.92
12/03/2007 11:48	0.93	0.91	0.95	0.92
12/03/2007 11:58	0.92	0.91	0.95	0.92

12/03/2007 12:08	0.92	0.9	0.96	0.9
12/03/2007 12:18	0.91	0.89	0.95	0.88
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12/03/2007 16:48	0.92	0.89	0.95	0.9
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12/03/2007 17:08	0.92	0.9	0.95	0.91
12/03/2007 17:18	0.92	0.89	0.93	0.92
12/03/2007 17:28	0.92	0.91	0.92	0.93
12/03/2007 17:38	0.92	0.91	0.92	0.92
12/03/2007 17:48	0.92	0.9	0.93	0.93
12/03/2007 17:58	0.92	0.91	0.92	0.93
12/03/2007 18:08	0.91	0.88	0.92	0.92
12/03/2007 18:18	0.92	0.91	0.93	0.93
12/03/2007 18:28	0.92	0.9	0.92	0.94
12/03/2007 18:38	0.93	0.91	0.93	0.93
12/03/2007 18:48	0.92	0.89	0.93	0.94
12/03/2007 18:58	0.91	0.89	0.92	0.92
12/03/2007 19:08	0.91	0.85	0.92	0.93
12/03/2007 19:18	0.93	0.89	0.95	0.94
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12/03/2007 19:38	0.93	0.88	0.95	0.95
12/03/2007 19:48	0.93	0.89	0.95	0.94
12/03/2007 19:58	0.91	0.88	0.93	0.92
12/03/2007 20:08	0.91	0.87	0.93	0.93
12/03/2007 20:18	0.9	0.86	0.93	0.91
12/03/2007 20:28	0.91	0.89	0.93	0.91
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12/03/2007 21:28	0.88	0.87	0.88	0.9
12/03/2007 21:38	0.86	0.86	0.87	0.86
12/03/2007 21:48	0.88	0.87	0.87	0.89
12/03/2007 21:58	0.88	0.86	0.88	0.89
12/03/2007 22:08	0.89	0.88	0.89	0.89
12/03/2007 22:18	0.9	0.88	0.9	0.91
12/03/2007 22:28	0.91	0.87	0.92	0.93
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12/03/2007 22:48	0.9	0.88	0.91	0.92
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12/03/2007 23:28	0.95	0.92	0.97	0.95
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13/03/2007 00:18	0.93	0.88	0.96	0.93
13/03/2007 00:28	0.95	0.93	0.96	0.95
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13/03/2007 00:48	0.95	0.93	0.97	0.94
13/03/2007 00:58	0.96	0.93	0.97	0.97
13/03/2007 01:08	0.96	0.93	0.97	0.97
13/03/2007 01:18	0.96	0.95	0.97	0.97
13/03/2007 01:28	0.96	0.93	0.96	0.97
13/03/2007 01:38	0.95	0.92	0.96	0.97
13/03/2007 01:48	0.96	0.93	0.97	0.98
13/03/2007 01:58	0.96	0.94	0.97	0.97
13/03/2007 02:08	0.96	0.92	0.98	0.97
13/03/2007 02:18	0.96	0.93	0.97	0.97
13/03/2007 02:28	0.96	0.92	0.97	0.97
13/03/2007 02:38	0.96	0.92	0.98	0.97
13/03/2007 02:48	0.96	0.93	0.98	0.97
13/03/2007 02:58	0.97	0.91	0.99	0.97
13/03/2007 03:08	0.96	0.93	0.98	0.96
13/03/2007 03:18	0.96	0.94	0.98	0.97
13/03/2007 03:28	0.96	0.93	0.97	0.97
13/03/2007 03:38	0.96	0.94	0.98	0.97
13/03/2007 03:48	0.96	0.93	0.97	0.97
13/03/2007 03:58	0.96	0.92	0.97	0.97
13/03/2007 04:08	0.96	0.92	0.97	0.97
13/03/2007 04:18	0.96	0.93	0.97	0.96
13/03/2007 04:28	0.96	0.93	0.97	0.97
13/03/2007 04:38	0.97	0.95	0.97	0.98
13/03/2007 04:48	0.97	0.96	0.97	0.98
13/03/2007 04:58	0.96	0.94	0.97	0.97
13/03/2007 05:08	0.96	0.94	0.97	0.97
13/03/2007 05:18	0.96	0.93	0.97	0.97

13/03/2007 05:28	0.96	0.93	0.96	0.98
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13/03/2007 05:58	0.96	0.95	0.96	0.97
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13/03/2007 06:18	0.95	0.94	0.93	0.97
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13/03/2007 07:38	0.94	0.94	0.94	0.93
13/03/2007 07:48	0.93	0.92	0.94	0.93
13/03/2007 07:58	0.93	0.93	0.94	0.92
13/03/2007 08:08	0.93	0.94	0.94	0.91
13/03/2007 08:18	0.93	0.93	0.95	0.9
13/03/2007 08:28	0.92	0.92	0.94	0.9
13/03/2007 08:38	0.92	0.92	0.94	0.89
13/03/2007 08:48	0.93	0.93	0.95	0.9
13/03/2007 08:58	0.93	0.93	0.95	0.92
13/03/2007 09:08	0.94	0.93	0.96	0.92
13/03/2007 09:18	0.93	0.93	0.95	0.91
13/03/2007 09:28	0.94	0.93	0.95	0.92
13/03/2007 09:38	0.94	0.93	0.96	0.93
13/03/2007 09:48	0.94	0.93	0.97	0.92
13/03/2007 09:58	0.94	0.92	0.96	0.92
13/03/2007 10:08	0.93	0.92	0.96	0.91
13/03/2007 10:18	0.94	0.92	0.96	0.92
13/03/2007 10:28	0.94	0.92	0.97	0.91
13/03/2007 10:38	0.93	0.92	0.96	0.91
13/03/2007 10:48	0.93	0.92	0.96	0.9
13/03/2007 10:58	0.94	0.93	0.96	0.92
13/03/2007 11:08	0.94	0.92	0.96	0.92
13/03/2007 11:18	0.93	0.92	0.96	0.91
13/03/2007 11:28	0.92	0.9	0.96	0.89
13/03/2007 11:38	0.92	0.91	0.96	0.89
13/03/2007 11:48	0.92	0.92	0.95	0.89
13/03/2007 11:58	0.92	0.91	0.96	0.89
13/03/2007 12:08	0.93	0.92	0.96	0.89
13/03/2007 12:18	0.93	0.92	0.96	0.9
13/03/2007 12:28	0.93	0.92	0.96	0.9
13/03/2007 12:38	0.92	0.9	0.96	0.89
13/03/2007 12:48	0.93	0.91	0.97	0.89
13/03/2007 12:58	0.92	0.89	0.96	0.88
13/03/2007 13:08	0.92	0.89	0.96	0.88
13/03/2007 13:18	0.92	0.89	0.95	0.9
13/03/2007 13:28	0.91	0.88	0.95	0.9

جامعة النجاح الوطنية
كلية الدراسات العليا

وسائل إدارة الطاقة ونتائج مسح الطاقة الكهربائية، الحرارية وتطبيقات الطاقة الشمسية في قطاع المستشفيات في فلسطين

إعداد
بشار عدلي شكري دعاس

إشراف
د. عماد بريك
د. وليد الكخن

قدمت هذه الاطروحة استكمالاً لمتطلبات الحصول على درجة الماجستير في هندسة الطاقة النظيفة وترشيد الاستهلاك من كلية الدراسات العليا في جامعة النجاح الوطنية في نابلس، فلسطين.

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الملخص

تعتبر المشفيات ومبانيها المستهلك الأكبر للطاقة، والتي يتم استخدامها بطرق كثيرة ومتعددة. لقد برهنا بنجاح في هذه الأطروحه أن هناك كمية ضخمة في توفيرات الطاقة في قطاع المشفيات الفلسطينية (10%–25 %) وذلك بتطبيق إجراءات ترشيد استهلاك الطاقة (بدون أو بإستثمار منخفض) على معظم التجهيزات المستهلكة للطاقة مثل البويلرات، ووحدات توليد الأوكسجن، وأنظمة التبريد، ونظام الإنارة، وسخانات المياه الشمسية واخرى.

إن فعالية إستخدام الطاقة وإدارتها في المشفيات الفلسطينية ليست في وضع أفضل من معظم الدول النامية. لذلك حاولنا أن نبدأ بخطوة اولية نحو إستعمال فعال للطاقة وإدارتها في المشفيات من خلال إجراء عدة مسوحات في مشفيات مختلفة حيث الإنارة، والتبريد، ووحدة توليد الإوكسجين، ومعامل القدرة او مستويات خدماتية اخرى، والتي يمكن تخفيضها دون المس بالرعاية الصحية ووسائل الراحة.

لقد حققنا نسبة مئوية يبلغ إجمالي معدل توفيراتها 17% للمشفيات، 14% للتدفئة والتبريد، 43% لنظام توليد الأوكسجين، 17% من معامل القدرة و 5% من نظام الإنارة.