



Rationalization of Energy Consumption in Large Buildings by Using

Technical Methods and Thermal Insulation.

(Case Study: Palestinian Territories)

By

Eng. Anas Khader Ahmed Antari

Supervisor

Dr. Walid M Emar

A Thesis Submitted in Partial Fulfilment of the Requirements for Master

Degree of Science in Engineering projects management

Faculty of Graduate Studies

Isra University

June , 2019

DECISION OF THE DISCUSSION COMMITTEE

This Thesis (Rationalization of Energy Consumption in Large Buildings by Using Technical Methods and Thermal Insulation, (Case Study: Palestinian Territories)) was successfully defended and approved on 11-June-2019.

Examination Committee

Signature

Associate Prof. Dr. Walid M.Emar (Supervisor)

.....

Isra University

Amman-Jordan.

Assistant Prof. Dr. Osama Fares (Member)

.....

Isra University

Amman-Jordan

Prof. Dr. Marwan Al-Nsour (Member)

.....

Al Balqa Applied University

Amman-Jordan

AUTHORIZATION FORM

I, Anas Khader Ahmed Antari, authorize Isra University to supply copies of my Thesis to libraries or establishments or individuals on request, in accordance to the University regulations.

Signature:

Date:

ACKNOWLEDGMENT

Praise be to Allah, who empowered me to do this research. I am very grateful to my principal supervisor, Dr. Waïd Emar for his deep remarkable suggestions and his guidance on my research. He was always friendly and modern in his teaching approach. I would like to extend my thanks to the faculty members who have enriched my knowledge and have added great value to my perspectives of scientific research.

I owe to my parents for their ceaseless support. Unforgettably, I highly value the great sacrifice and support of my sister , Engineer Ahlam Antari and my cousin Maen Antari, which have heightened my determination to pursue this study. As well as contributed tremendously for the successful completion of this work.

I would like to convey my immense thanks and sincere appreciation to my friend Mr Hussen Aydy, who has supported me to pursue my master degree. Also, great appreciation goes to Mr Samer Ahmad for his support during the study period.

TABLE OF CONTENTS

DECISION OF THE DISCUSSION COMMITTEE.....	I
AUTHORIZATION FORM.....	II
ACKNOWLEDGMENT	III
TABLE OF CONTENTS.....	IV
LIST OF TABLES.....	VII
LIST OF FIGURES	X
LIST OF ABBREVIATIONS.....	XII
ABSTRACT	XIV
CHAPTER ONE: INTRODUCTION.....	1
1.1 INTRODUCTION.....	1
1.2 LITERATURE REVIEW.....	4
1.3 RESEARCH PROBLEM	10
1.4 RESEARCH HYBOTHESIS	10
1.5 METHODOLOGY	10
1.6 STRUCTURE AND OUTLINE	11
CHAPTER TWO: GENERAL SITUATION OF ENERGY IN THE PALESTINIAN TERRITORIES.....	13
2.1 POPULATION IN THE PALESTINIAN TERRITORIES	13
2.2 ENERGY SECTOR IN THE PALESTINIAN TERRITORIES	13
2.3 POWER SUPPLY IN THE PALESTINIAN TERRITORIES	15
2.4 ENERGY CONSUMPTION IN PALESTINIAN TERRITORIES	19
2.5 GENERAL STATUS OF RENEWABLE ENERGY SOURCES IN THE PALESTINIAN TERRITORIES.....	27
2.6 GENERAL STATUS OF ELECTRICITY IN THE PALESTINIAN TERRITORIES.....	29
CHAPTER THREE: ENERGY MANAGEMENT PROCEDURES IN THE LARGE BIULDINDS.....	39
3.1 ENERGY MANAGEMENT CONCEPT AND MEANS (EMO)	39
3.2 ENERGY CONSERVATION PROCEDURES IN LIGHTING SYSTEMS.....	41
3.3 ENERGY CONSERVATION PROCEDURES IN BOILER SYSTEM.....	42
3.4 ENERGY CONSERVATION PROCEDURES IN AIR CONDITIONERS.....	48
3.5 IMPROVE THE POWER FACTOR.....	49

3.6	THERMAL APPLICATIONS BY SOLAR ENERGY	50
-----	--	----

CHAPTER FOUR: AN OVERVIEW OF THE STATUS OF ENERGY MANAGEMENT IN PALESTINIAN UNIVERSITY

BUILDINGS 53

4.1	THE UNIVERSITY SECTOR IN THE PALESTINIAN TERRITORIES	53
4.2	SOURCES OF HOT WATER IN THE UNIVERSITY SECTOR	56
4.3	CURRENT REALITY OF ENERGY MANAGEMENT IN THE UNIVERSITY SECTOR	56
4.4	LINKING THEORETICAL REALITY TO PRACTICAL IN PALESTINIAN UNIVERSITIES.....	57

CHAPTER FIVE : RATIONALIZATION OF ELECTRICAL ENERGY (CONCEPT, IMPORTANCE AND RESPONSIBILITIES) 60

5.1	THE STRATEGY OF THE MINISTRY OF ELECTRICITY AND ENERGY TO MEET THE DEMAND FOR ELECTRICITY CONSUMPTION	60
5.2	THE CONCEPT OF ELECTRIC POWER CONSUMPTION	60
5.3	IMPORTANCE AND BENEFITS OF ENERGY CONSERVATION	61
5.4	ENERGY CONSERVATION FROM ECONOMIC PERSPECTIVE	61
5.5	ENERGY CONSERVATION FROM RELIGIOUS PERSPECTIVE	62
5.6	THE ROLE OF STATE INSTITUTIONS	62
5.7	THE ROLE OF GOVERNMENT MINISTRIES.....	63
5.8	ROLE OF DIFFERENT MINISTRIES.....	64
5.9	CIVIL SOCIETY ORGANIZATIONS	66
5.10	THE ROLE OF THE SOCIETY AND THE INDIVIDUAL.....	68
5.11	ROLE OF RENEWABLE ENERGIES AND ENERGY EFFICIENCY	68

CHAPTER SIX : RATIONALIZATION OF ELECTRICAL ENERGY (EFFORTS OF THE ELECTRICITY SECTOR AND PROCEDURES REQUIRED BY CITIZENS) 70

6.1	INTRODUCTION.....	70
6.2	IMPROVING THE ELECTRIC SUPPLY EFFICIENCY	71
6.3	RATIONALIZATION OF ELECTRICITY CONSUMPTION	71
6.4	GENERAL MEANS AND GUIDELINES FOR THE RATIONALIZATION OF HOUSEHOLD ENERGY FOR ELECTRICAL EQUIPMENT AND APPLIANCES	75
6.5	RATIONALIZATION OF ELECTRICAL POWER CONSUMPTION OF ELECTRICAL EQUIPMENT AND APPLIANCES IN THE WORKPLACE.....	93

6.6	RATIONALIZATION OF ELECTRICITY CONSUMPTION IN LIGHTING SYSTEMS .	93
-----	--	----

CHAPTER SEVEN: RATIONALIZATION OF ENERGY CONSUMPTION USING THERMAL INSULATION.....98

7.1	INTRODUCTION.....	98
7.2	DEFINITION OF THERMAL INSULATION	99
7.3	THERMAL TRANSFER COEFFICIENT	99
7.4	THERMAL CONDUCTIVITY COEFFICIENT	99
7.5	CLASSIFICATION OF THERMAL INSULATION MATERIALS IN TERMS OF FORM, COMPOSITION AND STRUCTURE	99
7.6	BASIC CRITERIA FOR THE SELECTION OF THERMAL INSULATION	103
7.7	THE QUALITY OF THE MANUFACTURING OF THERMAL INSULATION	106
7.8	THE ECONOMIC FEASIBILITY OF THERMAL INSULATION	106
7.9	SOME HEAT-INSULATING MATERIALS AND THEIR ADVANTAGES	106
7.10	COMPARISON OF THERMAL INSULATION MATERIALS IN TERMS OF IN TERMS OF THE MINIMUM THICKNESS TO ISOLATE THE WALLS AND THE MINIMUM THICKNESS OF THE INSULATION OF THE CEILING	113
7.11	FEASIBILITY STUDY OF ENERGY AND MINERALS REGULATORY COMMISSION BUILDING ISOLATION USING POLYETHYLENE	114

CHAPTER EITHG: CONCLUSIONS AND

RECOMMENDATIONS..... 120

8.1	CONCLUSIONS	120
8.2	RECOMMENDATIONS	123

9 REFERENCES 125

LIST OF TABLES

Table 2.1: Selected indicators of the performance of the energy sector in the Palestinian `territories during the years 2014-2017	15
Table 2.2: Energy Imported in Palestinian Territories in 2017.....	16
Table 2.3: Imported energy for the West Bank and Gaza Strip for 2016. Central Bureau of Statistics.....	18
Table 2.4: Household consumption rate in the West Bank for various forms of energy during the month of January 2015..	20
Table 2.5: Selected indicators of the residential sector in the Palestinian Territory during the period 2009 - 2015	21
Table 2.6: Relative Distribution of Households in the West Bank according to the Types of Energy Used to Heat Water during the Month of January 2015 ...	22
Table 2.7: Relative Distribution of Households in the West Bank according to the Types of Energy Used to Heat Water during the Month of January 2015 ...	24
Table 2.8: Quantity of electricity available in the Palestinian territories and their sources during 2010-2017.....	30
Table 2.9 : Peak load and power consumption in the main areas of west bank (estimated).....	31
Table 2.10: GDP in Palestine during 2014 and 2015	32
Table 2.11: Basic economic indicators for the Palestinian territories for 2016 and 2017	33
Table 2.12: Electricity Imported and Purchased in the West Bank for 2016..	37
Table 2.13: Average consumer prices for various forms of energy in the West Bank for 2016.....	38

Table 3.1: Standard ratios of excess air and appropriate oxygen volume	43
Table 4.1: Governmental and non-governmental universities located in the Palestinian territories	55
Table 6.1: The capacity of some cooling capacities for air conditioners available in the market.....	78
Table 6.2: The limits of the cooling capacity in unit (BTU) depending on the area in the unit (square meter). Note: 1 kWh = 3415 BTU.....	79
Table 6.3: Estimated amount of hot water used.....	82
Table 6.4: Estimated amount of water of washing machines with the upper door.....	83
Table 6.5: Comparison of electricity consumption with wash cycle when reducing the control temperature	84
Table 6.6: Refrigerator\freezer estimated monthly consumption (kWh).....	89
Table 6.7: Refrigerator monthly consumption by size	90
Table 6.8: Freezer monthly consumption by size	90
Table 6.9 : The power of some electrical and electronic devices and standby Capability.....	93
Table 6.10: Maximum permissible optical power density.....	94
Table 6.11: The available capacities, amount of light and light efficiency of incandescent bulbs.....	95
Table 6.12: the characteristics of Fluorescent Light Bulbs.....	96
Table 6.13: A comparison between the capacity of ordinary lamps and the equivalent of integrated lamps provided.....	97

Table 7.1: Comparison of thermal conductivity coefficients of polyurethane with other materials.	112
Table 7.2: Comparison of insulation materials in terms of thickness of insulation of walls and ceilings..	113
Table 7.3: The economic analysis.	119

LIST OF FIGURES:

Figure 2.1: Consumption ratios of Palestinian energy sectors for 2015.....	19
Figure 2.2: Relative Distribution of Households in the West Bank and a Contribution to the Availability and Use of Solar Heaters during the Month of January 2015.....	23
Figure 2.3: Percentage of households with different means of heating in the West Bank during the month of January 2015.....	23
Figure 2.4: Percentage distribution of families who are preparing bread in various forms of energy according to each region in the West Bank of the month of January 2015.....	25
Figure 2.5: Electricity consumption per capita for a number of Arab countries for 2011.....	26
Figure 2.6: Monthly wind speeds for the Palestinian territories.....	27
Figure 2.7 : Daily average solar insolation in the west bank.....	28
Figure 2.8: Electricity consumption rates for different sectors of the Palestinian territories for 2011.....	36
Figure 3-1: The chart efficiency of the combustion of fuel type 2.....	45
Figure 3.2: The chart efficiency of the combustion of fuel type 6.....	46
Figure 3.3 : Illustration diagram of the main components of the boiler.....	47
Figure 3.4: Solar heaters used in the residential sector.....	51
Figure 4.1: Simplified drawing of thermal insulation.....	54
Figure 4.2: Illustration of the effect of thermal insulation on temperature.....	54
Figure 6.1: Illustration of the ordinary bulb	76
Figure 6.2 : Illustration of fluorescent bulb	76
Figure 6.3 : Components of air conditioning unit.....	81
Figure 6.4 : Components of the separated air conditioner unit.....	81
Figure 6.5: The amount of hot water used for the types of washing machines by size ...	83

Figure 6.6: Quantity of water used (estimated) for washing machines with a upper door.	83
Figure 6.7: Electricity consumption values for washing machines when decrease temperature to 50 °C and 60 °C.....	84
Figure 6.8: Maximum optical power density values for each type of room.....	94
Figure 7.1: Illustrates the form of solid polystyrene panels.....	101
Figure 7.2: Illustrates the form of glass wool panels.....	101
Figure 7.3: Illustrates the form of Polyurethane applied by injection.....	102
Figure 7.4 : Illustrates the form of double glass with Argon gas.....	106
Figure 7.5 : Illustrates the form of expanded polystyrene panels.....	108
Figure 7.6 : Illustration the form of Perlite granules.....	109
Figure 7.7 : Illustrates the form of Foam Polystyrene	111
Figure 7.8 : Chemical form of polyethylene	115
Figure 7.9: Illustration of polyethylene sheets.....	116

LIST OF ABBREVIATIONS

PCBS	The Palestinian Central Bureau of Statistics
PEA	Palestinian Energy Authority
PEC	Palestinian Electricity Company
PERC	Palestine Electricity Regulatory Council
PIPA	Palestinian Investment Promotion Agency
UNCTAD	United Nations Conference on Trade and Development
AUE	Arab Union of Electricity
EE	Energy Efficiency
MEMIP	Mediterranean Energy Market Integration Project
RCREEE	Regional Center for Renewable Energy and Energy Efficiency
CFFT	Complex Finite Fourier Transform
LPG	Liquefied Petroleum Gas
GDP	Gross Domestic Product
JEDCO	Jerusalem Distribution Electric Company
KWh	Kilo Watt Hour
KV	Kilovolt
KVA	Kilovolt Ampere
MW	Megawatt
MWh	Megawatt Hour
GWh	Gigawatt Hour
P. F	Power Factor
IEC	Israeli Electric Company

NGOs	Non-Governmental Organizations
BTU	British Thermal Units
HVAC	Heating, Ventilation, and Air Conditioning
SEEC	Saudi Energy Efficiency Center
CFL	Compact Fluorescent Lamps
HEMS	House Energy Management System
LCCA	Life-Cost Cycle Analysis
LCC	Life-Cost Cycle
PV	Present Value
FV	Future Value
IRR	The Internal Rate of Return
JD	Jordanian Dinar

ABSTRACT:

Electric power is undoubtedly one of the main pillars of economic and social development in modern times worldwide. In Palestine, as in the rest of the world, electric power has great importance; in some cases, it surpasses that of other nations because Palestine is a developing country under occupation aspiring to achieve an economic and social development free from the control of the Israeli occupation. The main objective of this thesis is to establish a pace toward the efficient use of energy and energy management in large or medium buildings through conducting several procedures in some different buildings where lighting, air-conditioning, oxygen generation units, power factor or other service levels can be reduced without detriment to comfort or health care. In this thesis, we will also define the concept and importance of rationalization of electric energy, and we will determine the responsibilities towards the rationalization of electric energy, the efforts of the electricity sector in the rationalization of electrical energy and procedures

Thermal insulation is one of the most important methods of energy conservation in buildings, which contributes to the preservation of the internal heat of buildings for long periods. In this thesis we will present an economic feasibility of thermal insulation, just to apply the economical strategies to determine the best heating and cooling isolation system (using polyethylene isolation materials) from the following alternatives: 1- Isolate all of floors and walls. 2-Isolate the walls. 3- Do nothing (Not use any isolation system) we have chosen a government building where the building consists of five floors, each has a 1950m², according to information obtained from the management of the building, the monthly bill for heating and lighting is 4,000JD. On other hand, 57% of the bill is for heating and cooling system and 43% is for lighting.

The economical engineering strategy that used in this study is life cycle cost analysis life (LCCA). The results show that using the polyethylene isolation materials to isolate walls will decrease the monthly bill to 55% and the IRR will be 16%. On other hand, isolated all walls and floors will decrease the monthly bill to 40% but the IRR will be 13%. The last alternative which is not using isolation were not accepted. Finally, the recommendation is to use alternative two; to save at least 121000 Jordan Dinars over 20 years, while 150000 Jordan Dinars will save if the building isolated all walls and floors over 20 years.