

ENERGY SAVING IN RESIDENTIAL BUILDINGS

By

Eng. Ahmad Sabry Abdel-Aleem Ali An-Naggar

**A Thesis Submitted to the Faculty of
Engineering at Cairo University in Partial
Fulfilment of the Requirements for the Degree of
Master of Science**

In

MECHANICAL POWER ENGINEERING

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ENERGY SAVING IN RESIDENTIAL BUILDINGS

Key Words: (Energy Saving – Energy Efficiency – Sustainability)

Summary:

The research in this thesis addresses the topic of energy consumption in residential buildings in Egypt. This topic represents a considerable section of the total electric energy generated by the electric power stations. A residential building consists of three floors and six apartments of 100 m^2 floor area for each apartment; this building has been drawn by software called “**Design-builder**” that also calculate the cooling load and the heating load for the left house on the 3rd floor (typical floor) on two cases; one with thermal insulation in the walls and the roof and the other without thermal insulation. This research illustrates by using “**Design-builder**” software three comparisons between the sensible cooling load, air-conditioner energy consumption rate, cost of the energy consumed and the CO₂ produced by power plant, due to the energy consumed on the two cases (with thermal insulation and without), at three different room temperatures.

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TABLE OF CONTENTS

List of Tables	ii
List of Figures	iii
Symbols and Abbreviations	viii
Nomenclatures	viii
List of abbreviations	x
Abstract	xi
CHAPTER 1 INTRODUCTION	1
1.1. World's Energy	1
1.2. Energy Prospects in Egypt	2
CHAPTER 2 LITERATURE REVIEW	7
CHAPTER 3 METHODOLOGY AND CALCULATIONS PROCEDURE	12
3.1. General	12
3.2. Methodology	13
3.2.1. Energy Calculation Concepts	13
3.2.2. Energy Estimating & Modeling Methods	14
3.3. Design Builder	17
3.3.1. Overview on Design Builder	17
3.3.2. Design Builder Capabilities	17
3.3.3. Design Builder Dialogs	19
3.3.4. Design Builder Simulation	21
3.3.5. Design Builder Outputs	21
3.4. Data Collection	27
3.5. Program Validation	29
CHAPTER 4 MATHEMATICAL MODELING	34
4.1. Introduction	34
4.2. Fluid Element for Conservation Laws	34
4.3. Substantial derivative	35
4.4. Governing equations	37
4.4.1. Mass conservation	37
4.4.2. Momentum equation	37
4.4.3. Energy equation	39
CHAPTER 5 CASE STUDY	44
5.1. General	44
5.2. Building Orientation	45
5.3 Cooling & Heating loads	46
5.3.1 Cooling load	46
5.3.2 Heating load	62
5.4 Internal CFD Analysis	69
5.4.1 Factors in Human Comfort	69
CHAPTER 6 RESULTS AND DISCUSSION	79
CHAPTER 7 CONCLUSIONS AND RECOMMENDATIONS	103
REFERENCES	105
APPENDIX A: Residential Cooling and Heating Load Calculations (ASHRAE Handbook, Fundamentals 2013 SI Edition)	107
APPENDIX B: Result of Manual Cooling Load Calculations	114
ملخص البحث	115

LIST OF TABLES

Table	Description	Page
1.1	Egypt's generated and consumed electricity	2
1.2	Energy consumption in Egypt according to the different sectors	3
1.3	Electricity tariff in Egypt	6
5.1	Best Orientation Analysis	46

LIST OF FIGURES

Figure	Description	Page
1.1	Global energy trends.	1
1.2	World energy consumption.	1
1.3	Percentage of electric consumption in Egypt.	3
1.4	Electric consumption in the industrial and the residential sectors in Egypt from 2009 to 2014.	4
1.5	Primary energy consumption in Egypt by fuel.	4
1.6	Petroleum and other liquids production and consumption in Egypt.	5
1.7	Dry natural gas production and consumption in Egypt.	5
3.1	Main flow chart of Energy Plus program.	13
3.2	Outside surface heat balance.	15
3.3	Inside surface heat balance.	16
3.4	Zone air Heat balance.	16
3.5	Iterative process of computer modelling in Designbuilder	19
3.6	Construction definition in DesignBuilder	20
3.7	Sample data from DesignBuilder	25
3.8	Example of External CFD analysis output- wind pressure study	26
3.9	Example of Internal CFD analysis output- occupant comfort	27
3.10.a	Room configuration, Case 1	29
3.10.b	Room configuration, Case 2	29
3.10.c	Room configuration, Case 3	30
3.11.a	Velocity contour of Case 1 from Phoenix.	31
3.11.b	Velocity contour of Case 1 from DesignBuilder.	31
3.12.a	Velocity contour of Case 2 from Phoenix.	32
3.12.b	Velocity contour of Case 2 from DesignBuilder.	32
3.13.a	Temperature contour of Case 3 from Phoenix.	33
3.13.b	Temperature contour of Case 3 from DesignBuilder.	33
5.1.a	Building Design Configuration.	44
5.1.b	Plan view of the third floor (typical floor).	44

5.2.a	Cross section of the wall for Case 1.	45
5.2.b	Cross section of the roof for Case 1.	45
5.2.c	Cross section of the wall for Case 2.	45
5.2.d	Cross section of the roof for Case 2.	45
5.3.a	Building with East orientation.	46
5.3.b	Building with South orientation.	46
5.4.a	Monthly internal gains for the 3 rd floor with East orientation, Case 1.	47
5.4.b	Monthly internal gains for the whole building with East orientation, Case 1.	47
5.5.a	Monthly internal gains for the 3 rd floor with South orientation, Case 1.	48
5.5.b	Monthly internal gains for the whole building with South orientation, Case 1.	48
5.6.a	Monthly internal gains for the living room with East orientation, Case 1.	49
5.6.b	Monthly internal gains for the living room with East orientation, Case 2.	49
5.7.a	Hourly internal gains for the living room with East orientation, Case 1.	50
5.7.b	Hourly internal gains for the living room with East orientation, Case 2.	50
5.8.a	Comfort in the living room with East orientation, Case 1.	51
5.8.b	Comfort in the living room with East orientation, Case 2.	51
5.9.a	Monthly heat gains for the living room with East orientation, Case 1.	52
5.9.b	Monthly heat gains for the living room with East orientation, Case 2.	52
5.10.a	Hourly heat gains for the living room with East orientation, Case 1.	53
5.10.b	Hourly heat gains for the living room with East orientation, Case 2.	53
5.11.a	Monthly internal gains for Bedroom 1 with East orientation, Case 1.	54
5.11.b	Monthly internal gains for Bedroom 1 with East orientation, Case 2.	54
5.12.a	Hourly internal gains for Bedroom 1 with East orientation, Case 1.	55
5.12.b	Hourly internal gains for Bedroom 1 with East orientation, Case 2.	55
5.13.a	Comfort in Bedroom 1 with East orientation, Case 1.	56
5.13.b	Comfort in Bedroom 1 with East orientation, Case 2.	56
5.14.a	Monthly heat gains for Bedroom 1 with East orientation, Case 1.	57
5.14.b	Monthly heat gains for Bedroom 1 with East orientation, Case 2.	57
5.15.a	Hourly heat gains for Bedroom 1 with East orientation, Case 1.	58

5.15.b	Hourly heat gains for Bedroom 1 with East orientation, Case 2.	58
5.16.a	Monthly internal gains for the whole building, Case 1.	59
5.16.b	Monthly internal gains for the whole building, Case 2.	59
5.17.a	Energy consumption rate for the whole building, Case 1.	60
5.17.b	Energy consumption rate for the whole building, Case 2.	60
5.18.a	CO ₂ emitted due to building energy consumption, Case 1.	61
5.18.b	CO ₂ emitted due to building energy consumption, Case 2.	61
5.19.a	Monthly internal gains for the 3 rd floor, Case 1.	62
5.19.b	Monthly internal gains for the 3 rd floor, Case 2.	62
5.20.a	Monthly internal gains for the living room, Case 1.	63
5.20.b	Monthly internal gains for the living room, Case 2.	63
5.21.a	Monthly internal gains for Bedroom 1, Case 1.	64
5.21.b	Monthly internal gains for Bedroom 1, Case 2.	64
5.22.a	Heat loss of the living room, Case 1.	65
5.22.b	Heat loss of the living room, Case 2.	65
5.23.a	Heat loss of Bedroom 1, Case 1.	66
5.23.b	Heat loss of Bedroom 1, Case 2.	66
5.24.a	Energy consumption rate for the whole building, Case 1.	67
5.24.b	Energy consumption rate for the whole building, Case 2.	67
5.25.a	CO ₂ emitted due to building energy consumption, Case 1.	68
5.25.b	CO ₂ emitted due to building energy consumption, Case 2.	68
5.26	PMV index & PPD index.	69
5.27.a	Temperature contour for maximum flow rate, Case 1.	70
5.27.b	Temperature contour for maximum flow rate, Case 2.	70
5.27.c	Temperature contour for minimum flow rate, Case 1.	71
5.27.d	Temperature contour for minimum flow rate, Case 2.	71
5.28.a	PMV contour for maximum flow rate, Case 1.	72
5.28.b	PMV contour for maximum flow rate, Case 2.	72
5.28.c	PMV contour for minimum flow rate, Case 1.	73

5.28.d	PMV contour for minimum flow rate, Case 2.	73
5.29.a	PPD contour for maximum flow rate, Case 1.	74
5.29.b	PPD contour for maximum flow rate, Case 2.	74
5.29.c	PPD contour for minimum flow rate, Case 1.	75
5.29.d	PPD contour for minimum flow rate, Case 2.	75
5.30.a	Velocity contour for minimum flow rate.	76
5.30.b	Velocity contour for maximum flow rate.	76
5.31.a	Calculation output data for maximum flow rate, Case 1.	77
5.31.b	Calculation output data for maximum flow rate, Case 2.	77
5.32.a	Calculation output data for minimum flow rate, Case 1.	78
5.32.b	Calculation output data for minimum flow rate, Case 2.	78
6.1.a	Sensible cooling load.	80
6.1.b	Air-conditioners energy consumption rate and energy saved.	80
6.1.c	Cost of energy consumed and money saved.	81
6.1.d	CO ₂ emitted due to energy consumed.	81
6.2.a	Sensible cooling load.	82
6.2.b	Air-conditioners energy consumption rate and energy saved.	82
6.2.c	Cost of energy consumed and money saved.	83
6.2.d	CO ₂ emitted due to energy consumed.	83
6.3.a	Sensible cooling load.	84
6.3.b	Air-conditioners energy consumption rate and energy saved.	84
6.3.c	Cost of energy consumed and money saved.	85
6.3.d	CO ₂ emitted due to energy consumed.	85
6.4.a	Sensible cooling load, Case 1.	86
6.4.b	Sensible cooling load, Case 2.	86
6.5.a	Air-conditioners energy consumption rate, Case 1.	87
6.5.b	Air-conditioners energy consumption rate, Case 2	87
6.6.a	Left-house energy consumption rate, Case 1	88
6.6.b	Left-house energy consumption rate, Case 2	88

6.7.a	Left-house electricity bill, Case 1	89
6.7.b	Left-house electricity bill, Case 2	89
6.8.a	CO ₂ emitted due to energy consumed, Case 1	90
6.8.b	CO ₂ emitted due to energy consumed, Case 2	90
6.9.a	Energy saved in summer.	91
6.9.b	Money saved in summer.	91
6.9.c	CO ₂ emission saved in summer.	92
6.10	Years for money pay-back.	93
6.11.a	Air-conditioners energy consumption rate, Case 1	94
6.11.b	Air-conditioners energy consumption rate, Case 2	94
6.12.a	Cost of energy consumed & money saved, Case 1	95
6.12.b	Cost of energy consumed & money saved, Case 2	95
6.13.a	CO ₂ emitted due to energy consumed, Case 1	96
6.13.b	CO ₂ emitted due to energy consumed, Case 2	96
6.14.a	Sensible heating load.	97
6.14.b	Heat-pumps energy consumption rate and energy saved.	97
6.14.c	Cost of energy consumed and money saved.	98
6.15.a	Sensible heating load.	98
6.15.b	Heat-pumps energy consumption rate and energy saved.	99
6.15.c	Cost of energy consumed and money saved	99
6.16.a	Sensible heating load, Case 1	100
6.16.b	Sensible heating load, Case 2	100
6.17.a	Heat-pumps energy consumption rate, Case 1	101
6.17.b	Heat-pumps energy consumption rate, Case 2	101
6.18.a	Cost of energy consumed, Case 1	102
6.18.b	Cost of energy consumed, Case 2	102
7.1	Louvre window	104
7.2	Overhang window	104

Symbols and Abbreviations

Nomenclature

Symbol

A	area, m ²
A_L	building effective leakage area (including flue) at 4 Pa, assuming
CD	1, cm ²
C_l	air latent heat factor, 3010 W/(L·s) at sea level
C_s	air sensible heat factor, 23 W/(L·s·K) at sea level
C_t	air total heat factor, 1.2 W/(L·s) (kJ/kg) at sea level
CF	cooling load factor, W/m ²
D_{oh}	depth of overhang (from plane of fenestration), m
DR	daily range of outdoor dry-bulb temperature, K
E	peak irradiance for exposure, W/m ²
F_{shd}	shaded fraction
FF	coefficient for CF_{fen}
G	internal gain coefficient
Δh	indoor/outdoor enthalpy difference, kJ/kg
H	height, m
HF	heating (load) factor, W/m ²
I	infiltration coefficient
IAC	interior shading attenuation coefficient
IDF	infiltration driving force, L/(s·cm ²)
k	conductivity, W/(m·K)
LF	load factor, W/m ²
OF	coefficient for CF_{opq}
p	perimeter or exposed edge of floor, m
PXI	peak exterior irradiance, including shading modifications
q	heating or cooling load, W
Q	air volumetric flow rate, L/s
R	insulation thermal resistance, (m ² ·K)/W
SHGC	fenestration rated or estimated NFRC solar heat gain coefficient

SLF	shade line factor
t	temperature, °C
T_x	solar transmission of exterior attachment
Δt	design dry-bulb temperature difference (cooling or heating), K
U	construction U-factor, W/(m ² ·K) (for fenestration, NFRC rated heating U-factor)
w	width, m
ΔW	indoor-outdoor humidity ratio difference, kg _w /kg _{da}
V	building volume, m ³
X_{oh}	vertical distance from top of fenestration to overhang, m
z	depth below grade, m
α_{roof}	roof solar absorptance
db	Dry-bulb temperature
rh	Relative humidity

List of Abbreviations

ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers
C.O.P	Coefficient of Performance
KWh	Kilowatt hour
BP	British Petroleum
OTTV	Overall Thermal Transfer Value
WWR	Window-to-wall ratio
CFD	Computational Fluid Dynamics
PMV	Predicted Mean Vote
PPD	Percentage Predicted Dissatisfied
SBEM	Simplified Building Energy Model
ECMs	Energy Conservation Measures
GW	Glass Wool
LEED	Leadership in Energy and Environmental Design
OECD	Organization for Economic, Co-operation & Development
NFRC	National Fenestration Rating Council
CSA	Canadian Standards Association
ceil	Ceiling
cf	conditioned floor
cl	Closed
es	exposed surface
exh	Exhaust
fen	Fenestration
i	Infiltration
in	Indoor
ig	internal gain
l	Latent
o	Outdoor
oc	Occupant
oh	Overhang
opq	Opaque
shd	Shaded