FINAL YEAR THESIS REPORT
BACHELOR DEGREE IN MECHANICAL ENGINEERING
FACULTY OF MECHANICAL ENGINEERING
MARA UNIVERSITY OF TECHNOLOGY
40450 SHAH ALAM

REDESIGNING AN INSTITUTIONAL BUILDING FOR LOW-ENERGY USING ENERGY-10 SOFTWARE

PREPARED BY:

RICHARD ANYI
CENDRIC MASUIL @ALEXANDER

NOVEMBER 1999

ABSTRACT

A simulation study on the thermal performance has been done on tropical institutional building at Shah Alam. The Energy-10 software was used for this purpose and the building chosen was the medium sized Faculty of Information Technology and Quantitative Science building at Universiti Teknologi MARA.

The main objectives of the project were to study the energy consumption, to analyze the possible energy saving by redesigning the building parameters and to make recommendations on the possible energy efficient designed strategies.

Eight cases were studied, including the reference case where existing building parameters were considered. It was found that a minimum of 10% of the total annual energy consumption could be saved by applying some energy efficient strategies while a maximum saving of 70% could be produced if all the design strategies including daylighting in the software were considered.

The capabilities and limitations of the software are discussed. Suggestions for improvement of the software and recommendations for energy efficient building design in a tropical setting are also included in this report.

TABLE OF CONTENTS

CONTENTS			PAGE
ACKNOWLEDGEMENT			**I**
ABSTRACT			**II**
TABLE OF CONTENTS			

CHAPTER ONE

1	INTRODUCTION		1
	1.1	DEFINITION	2
		1.1.1 Energy-efficient strategy	2
		1.1.2 Daylighting	3
		1.1.3 HVAC System	3
		1.1.4 Materials	4
		1.1.5 Lighting	5
		1.1.6 Shading	5
	1.2	DESIGN AND ANALYSIS TOOL	6
		1.2.1 Energy-10	6
	1.3	OBJECTIVES	7
		1.3.1 To study the Energy-10 software	7
		1.3.2 To study energy consumption of present building	7
		1.3.3 To redesign existing institutional building for low energy building using Energy-10 software	7
		1.3.4 To analyze the possible energy savings in building	8
		1.3.5 To recommend the design parameters for energy efficient building	8
	1.4	SUMMARY	8

CHAPTER TWO

2	THEORY, EQUATIONS AND CALCULATION		10
	2.1	FUNDAMENTALS OF HUMAN COMFORT-Definitions	10
		2.1.1 Temperatures	10
		2.1.2 Conduction, Convection and Radiation	10
		2.1.3 Air Volume and Movement	11
		2.1.4 Activity and Clothing	12
		2.1.5 Air Purity	12
		2.1.6 Humidity	12
		2.1.7 Ionization	12
	2.2	SOLAR RADIATION IN MALAYSIA	13
	2.3	LOAD SOURCES	13
		2.3.1 Sensible	13
		2.3.2 Latent	14
		2.3.3 Steam Loads	14
		2.3.4 Internal Loads	15
	2.4	HEAT GAINS	15
	2.5	COOLING LOAD	16
	2.6	EQUATIONS FOR BUILDING MATERIALS CALCULATION	19

CONTENTS **PAGE**

2.6.1 Unit for Heat Flow 19
2.6.2 Heat Loss 20
2.6.3 Heat Gain 22
2.6.4 Infiltration 23
2.7 SAMPLE OF CALCULATION 24

CHAPTER THREE

3 INTRODUCTION 29
3.1 ENERGY EFFICIENT STRATEGIES 30
3.1.1 Daylighting 30
3.1.2 Glazing 31
3.1.3 Shading 32
3.1.4 Energy Efficient Lighting 33
3.1.5 Lighting Control 34
3.1.6 Insulation 35
3.1.7 Air Leakage Control 36
3.1.8 Thermal Mass 36
3.1.9 Passive Solar Heating 37
3.1.10 Natural Ventilation 38
3.1.11 Economizer Cycle 38
3.1.12 Exhaust Air Heat Recovery 40
3.1.13 High Efficiency HVAC 40
3.1.14 HVAC Control 41
3.1.15 Evaporative Cooling 41
3.1.16 Solar Hot Water Heating 42
3.2 ENERGY-10 43
3.2.1 Autobuild 44
3.2.2 Reference Case 45
3.2.3 Low-Energy Case 45
3.2.4 Apply 46
3.2.5 Rank 46
3.2.6 Using Energy-10 to incorporate the Energy Efficient Strategies 47
3.2.7 Steps to use Apply Features 47
3.2.8 Steps to use Rank Features 48
3.2.9 Steps to Customize Apply and Rank Actions 48
3.3 FTMSK BUIDING 50
3.3.1 Computer Lab Parameters and Materials 50
3.3.2 Lecturer's office Parameters and Materials 53

CHAPTER FOUR

4 METHODOLOGY 58
4.1 PRIMARY METHODOLOGY 59
4.1.1 Study of Energy-10 Software 61
4.1.2 Interviews Authorities 62

CONTENTS **PAGE**

4.1.3 Data and Information Research 62
4.1.4 Data and Information Input 63
4.1.5 Downloading Weather Data 63
4.1.6 Simulation 64
4.1.7 Analyzing the Results 66
4.2 DESIGN METHODOLOGY 67
4.2.1 Pre-Design Process 69
4.2.2 Elimination Parametric 69

CHAPTER FIVE

5 RESULT AND ANALYSIS 71
5.1 CASE 1 – CALCULATION ANALYSIS 74
5.2 CASE 2 – CALCULATION ANALYSIS 77
5.3 CASE 3 – CALCULATION ANALYSIS 80
5.4 CASE 4 – CALCULATION ANALYSIS 83
5.5 REDESIGN 1 – CALCULATION ANALYSIS 86
5.6 REDESIGN 2 – CALCULATION ANALYSIS 89
5.7 REDESIGN 3 – CALCULATION ANALYSIS 92
5.8 REDESIGN 4 – CALCULATION ANALYSIS 95
5.9 KEEP RESULT ANALYSIS CALCULATION 101

CHAPTER SIX

6 DISCUSSION AND CONCLUSION 105
6.1 DISCUSSION 106
6.2 ENERGY-10 CAPABILITIES AND LIMITATIONS 108
6.2.1 Energy-10 Capabilities 108
6.2.2 Energy-10 Limitations 109
6.3 SUGGESTIONS AND RECOMMENDATIONS 110
6.4 CONCLUSIONS 111

REFERENCES

APPENDICES
1. Appendix A: Conversion Factors
2. Appendix B: ASHRAE Standard Tables
3. Appendix C: Building Plan and Cases Sample