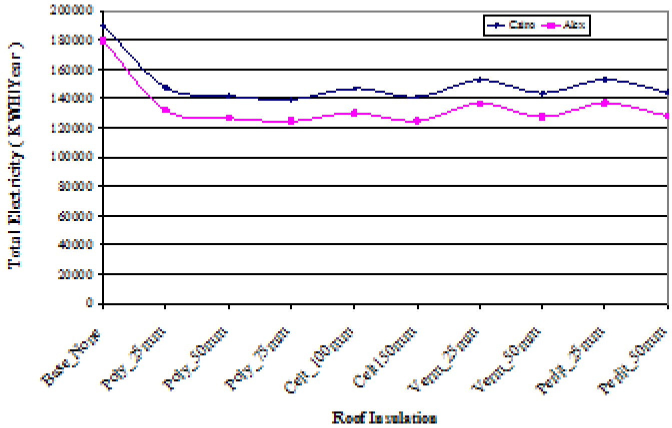

Figure 7: Effect of Roof insulation on the total electricity **consumption (KWh), Top Floor - Rec. (7x15 module)**

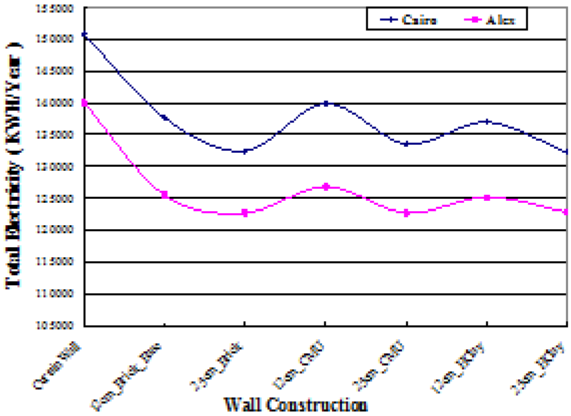

Figure 8: Effect of wall construction on the total electricity consumption (KWH), Mid. Floor - Rec. (7x 15 modules**).**

The resulting annual energy results are shown in Figure 7. The results indicate that the use of 75mm_Poly of roof insulation has the most impact, but the difference in the total Electricity (kWh/Year) between 75mm Poly and 50mm_Poly is not visible. The annual Electricity saving percent of 30% has been achieved for Cairo relative to 22% for Alexandria. The same saving in the total Electricity reduction could be reached, if we use 150mm_Celton, or 50mm_Perlit.

6.3 Wall Construction and Insulation

Three types of construction were examined with two insulation locations for one of the constructions. The first type consist of Curtain wall with aluminum or glass on the outside, then insulation, then air space, then a layer of gypsum board on the inside. The second type consists of 120mm hollow clay brick with mortar on both sides with rigid insulation on the inside between the brick and the mortar type. The third type contains 250mm hollow clay brick with mortar on both sides and rigid insulation in the middle between the two courses of clay. A wide range of wall construction were examined namely; 120mm_Brick (**BC**), 250mm_Brick, 120mm_CMU, 120 & 250mm_HClay. Five insulation systems and two locations (in & out) were tested i.e., none (**BC**), 10mm, 25mm, 50mm & 75mm thick. The energy results are shown in Figures 4 indicates that the use of 250mm thick Clay Brick or 250mm CMU has much saving than 120mm thick Brick or CMU. The annual saving in the total electricity reaches to 2.1% and 3.5% relative to 12cm brick and 12cm CMU. The change in the wall building materials in Cairo has much impact greater than Alexandria by about 7.2%. Increasing the wall insulation thickness greater than 25mm had diminishes.

6.4 Windows-to-Wall Ratio (WWR)

The window-to-wall ratio (WWR) is the ratio of the total glass area to the total building wall area (including the glass area) for all elevations of the building together. WWR directly affects the amount of solar heat gain entering the building, thus it has a great impact on energy consumption of the whole building. The Base Case (BC) for large office building in Egypt uses WWR=0.4. For the parametric analysis, single variable, has been changed across a wide range of values from 0.1 till 0.9.

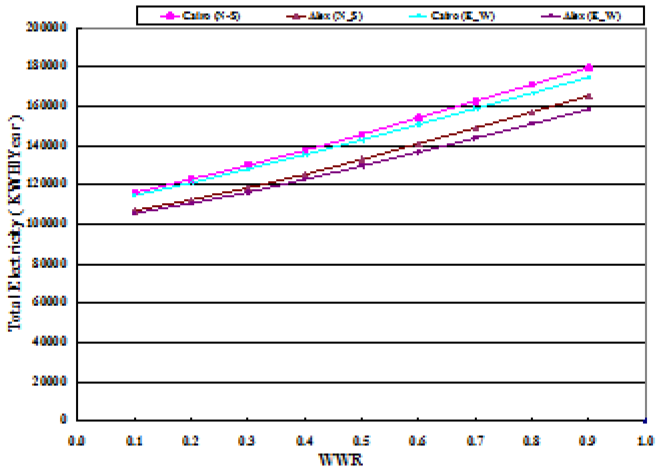

Figure 9: Effect of Window to Wall Ratio on the total electricity consumption (KWh), Mid. Floor -Rec. *(7x 15 modules).*

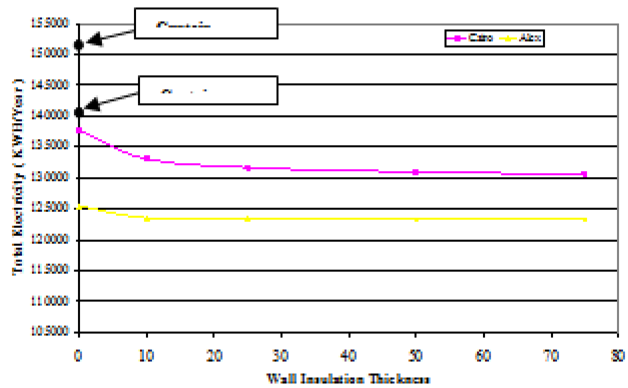

Figure 10: Effect of wall insulation on the total electricity consumption (KWh), Mid. Floor - Rec. (7x15 module)

6.5 Glass Type-Solar Heat Gain Coefficient (SHGC)

The Base Case for large office building in Egypt uses Glass Type 1P_SHGC_61. For the parametric analysis the SHGC, single variable, has been changed across a wide range. All nine fenestration options use regular aluminum frames, with no thermal breaks. Four of the nine options use a single pane of glass, while two options use double-pane, or two panes of glass. The double-pane options have a low emissivity coating on the inside pane of glass.

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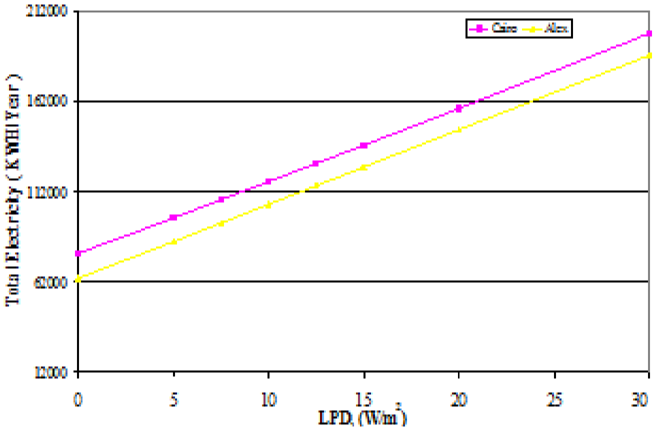

Figure 14: Effect of LPD on the total electricity Consumption (KWh), Mid Floor - Rec. (7x 15 modules).

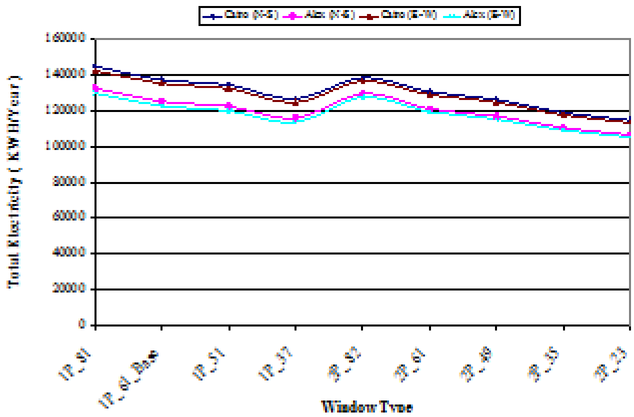

Figure 11: Effect of window type on the total electricity consumption (KWh), Mid. Floor– Rec. (7x 15 modules)

The resulting annual energy results are shown in Figure 11. The results indicate that the type of glass used in large office buildings is an important variable. The range of SHGC values examined resulted in change in the total building electricity use of about 20%. In Cairo, reducing the SHGC from 0.81 to 0.23 will reduce the total electricity use by 20% and 18% in Alexandria.

6.6 Solar Shading Using Overhangs and Fins (PF)

The Base Case for the large office building in Egypt uses the following percent: 0,0.25,0.5,0.75,1.0 for both overhang

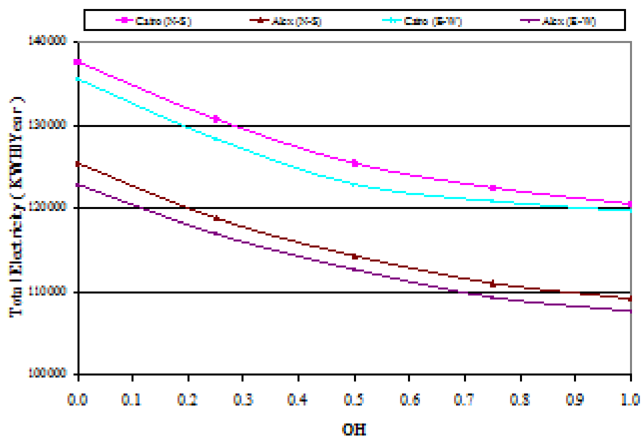

Figure 12: Effect of Over Hang (OH) on the total electricity consumption (KWh), Mid. Floor–Rec. (7x15) module.

The resulting annual energy results for overhangs and fins are shown in Figure 13. The results indicate that the projection factors of overhang and fin in a large office building are an important variable and can produce 6%-18% annual energy reduction depending on the building location, building orientation and the type of exterior shading used.

6.7 Installed lighting Power Density (LPD)

Lighting Power Density (**LPD**) is one of major part of energy consumption in office building. This section investigates the magnitude of influence of lighting power density on the building consumption. The Base Case of Large office building uses 15 W/m^2 where the variable being changed from 0 to 30 W/m^2.

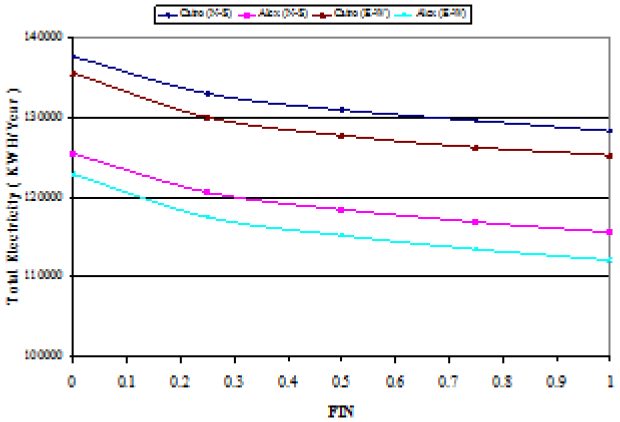

Figure13: Effect of FIN on the total electricity consumption (KWh), Mid. Floor - Rec. (7x15 module).

The annual energy results obtained are shown in Figure 9. The results indicate that the lighting power density level has a great impact on the annual energy use of office building. The energy consumption increased by about 80% when the light power level was increased from 5 to 25 W/m^2.

6.8 Air-Conditioning Systems (HVAC)

Five different HVAC system types are analyzed namely; **SUM**, **RESYS** (Residential System), **PSZ** (Package Single Zone), **TPFC** (Two Pipe Fan Coil), **VAV** (Variable Air Volume). Two typical systems in Egypt (**PSZ** and **TPFC**) were used.

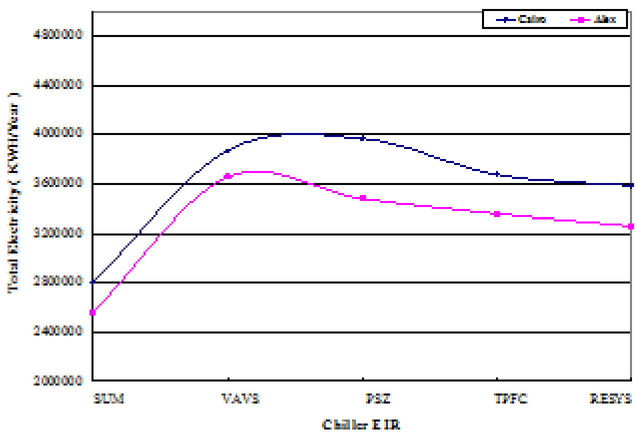

Figure 15: Effect of System Type on the total electricity consumption (KWh), LOF 20 - Rec. (7x15 module).

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For the building loads analyses above (envelope and lighting), we have used the SUM system, which tallies the loads on the HVAC system but does not include any system efficiency consideration. HVAC system selection can have a significant impact on building energy use, often producing total annual energy use variations in the range of 30%, as shown in Figure 10.

6.9 Air-Conditioning Chiller Efficiency (EIR)

The Base Case Chiller EIR is 0.25 for large Office building. The parametric analysis is varied from 0.286 to 0.16 for Cairo and Alexandria.

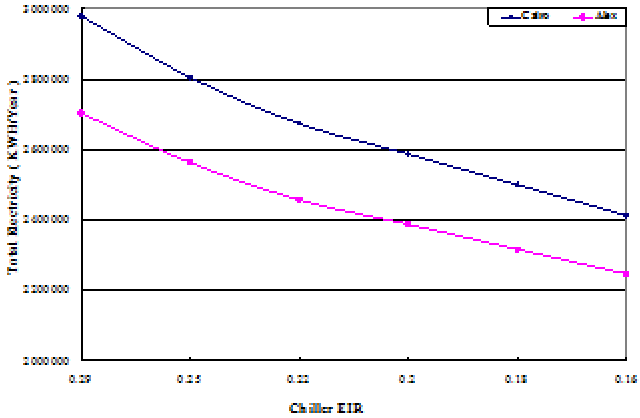

Figure 16: Effect of chiller EIR on the total electricity consumption (KWh), LOF 20 - Rec. (7x 15 modules).

6.10 Space Set-point Temperatures (SPT)

The Base Case for large office building in Egypt uses 23°C for the cooling set point during the occupied periods. The set point temperature is changed over the range of 18-29°C.

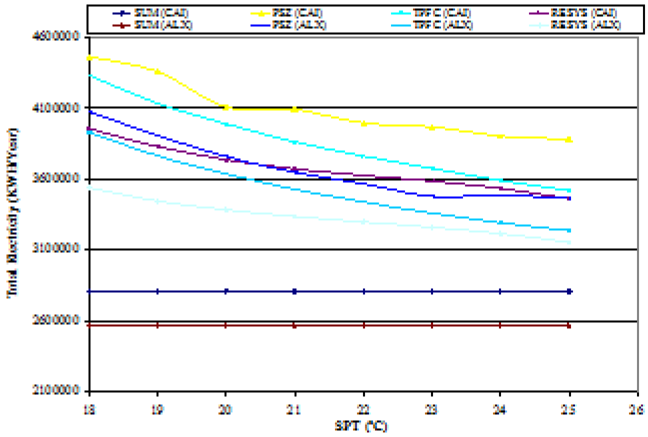

Figure 17: Effect of cooling SPT on the total electricity consumption (KWh), LOF 20 - Rec. (7x 15 modules) for Different HVAC Systems

The annual energy results are shown in Figure 12. The results indicate that total annual building energy consumption is reduced by about 10% when the cooling set temperature is increased from 18 to 29 °C. Thus for each degree C in set-point temperature there is 1% reduction in total building energy use and a 2% reduction in loads on the cooling system.

7. Conclusion

The energy consumption of large office buildings are major part of energy usage in Egypt, and this study reaches to significant findings results. A "Base Case" of Large Office "EG_LOF" was defined, and sets of potential energy saving measures are determined. The energy saving of each of these measures based on DOE2 parametric simulation, are shown in Table 5. The estimated results illustrates a considerable energy savings would reached by (1) starting with the Base Case Large Office that represents current practice, and then (2) changing the key energy-related features to comply with the requirements of the energy code, as shown in column 3. The items that we identified include: 1) Roof insulation; 2) Wall insulation; 3) Window-to-Wall Ratio (WWR); 4) Lighting Power Density; 5) Chiller EIR; 6) Glass Type (Solar Heat Gain Coefficient -SHGC)

The essence of this paper has illustrated how significant energy saving in office buildings can be achieved by judiciously selecting materials with appropriate design technique.

Table2: Large Office [2]

Parameter Studied	*Current Practice*	*Energy Code*	*Energy Saving*
Orientation	-	N-S	2%
WALL_CONSTRUCTION	12cm_Brick	25cm_HClay	2%
WALL_SURFACES	Mortar Both	Mortar Both	-
WALL_INSULATION	None	25mm_Out	2.5%
WINDOW_TYPE	1P_SHGC_61	1P_SHGC_37	6%
ROOF_INSULATION (Top Floor)	None	Poly_75mm	30%
WINDOW-TO-WALL-RATIO(WWR)	0.4	0.2	20%
SHADING USING OVERHANGS (OH) AND FINS (FINS)	-	N-S	10% 4%
OFFICE_LPD	15	15	-
OFFICE_EQPD	5	5	-
Set-Point Temperatures	22	24	2%
CHILLER_EIR	0.253	0.182	8%

Acknowledgment

The author wishes to acknowledge the chairperson of HBRC and all the simulation working group team.

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Author Profile

George Bassili Hanna received his Ph.D. from Liverpool University, Department of Building Engineering, U.K., in July 1974. During the period 1977-1980, He on live to the Department of Mechanical Engineering, Riyadh University, Saudi Arabia. He received the Egyptian Encouragement State Prize for Engineering Science, 1992 and a Pendant of First Class & Certificate from, the President of Egypt, 1995**.** He was Committee Coordinator and Team Leader of Simulation Working Group from 1999 to 2010, to develop the Egyptian Energy Codes for residential, commercial and Governmental Buildings in Egypt (in English and Arabic). He adds a new chapter in the codes about Natural Ventilation and Thermal Comfort.

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