STANDARDIZING THE ANNUAL ELECTRIC ENERGY CONSUMPTION FOR A RESIDENTIAL BUILDING IN BASRAH CITY

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***Abstract*- The present work is aimed to reduce the annual electric energy consumption in a residential building in Basrah city through introducing a standardized rule for the annual electrical consumption for the cooling and heating purposes.**

This work will concentrate on all parameters which help to go toward the optimum use of thermally efficient house. The building energy analysis program e-Quest was used to simulate the annual energy consumption for a typical residential house built with different types of building materials. Transfer function cooling load calculation was used. The results showed that for the Base- House, the thermal transmission through the walls and roof constitutes more than half of the total peak cooling load. It was found that a house built with thermo-stone causes 5.9% reduction of the annual cooling energy consumption, and 12.4% in the annual heating energy consumption. However, insulating the Base- House causes a significant reduction in the air conditioning equipment capacity and consequently reduction in cooling energy consumption by 23%, and reduces the heating energy consumption by 42.8%. Finally this work presents a useful planning to developed building design which reduces the electrical energy consumption

1. Introduction

Having briefly looked at the electrical energy consumption in the air conditioned buildings will show the size of the problem, so it is useful to outline the problem.

The climate in Basrah is very hot in summer and fairly cold in winter, therefore the cooling season is long and extends over eight months of the year. Correspondingly, the indoor temperature is affected by the details of the thermal properties of the building materials, building geometry, geographic orientation and all elements of building envelop.

The large masses, high specific heats and low thermal conductivity , walls, roof, floor and partition walls act as delay and attenuator elements to the external temperature fluctuation " temperature wave " . The time constant involved is in order of days in some cases . By controlling wall thickness , wall construction materials , orientation, wall colors, window size , window closing, and ventilation rate and using insulation layers in the wall …. etc., the amount of delay can be varied and the amount of heat intake could be changed .

Analysis of the energy performance of an air-conditioned building is a highly complex matter involving climate, building type, air conditioning system, and user interactions. Building envelope design, air-conditioning and lighting system design, occupancy patterns, operating schedules, and meteorological conditions detect building energy performance. An exploratory study of this type is only possible with the use of computers. Several computer programs are available for the calculation of building cooling and heating loads [1], but only a few are capable of detailed thermal simulation of both building materials and systems and performing hour by hour energy analyses. e-Quest and BLAST are two such comprehensive and widely used programs. The e-Quest has the ability to simulate a wide variety of energy conservation measures in buildings and it has been widely tested for accuracy. Energy simulations for buildings using e-Quest have been carried out for many climatic conditions.

2. Location and Climate

The model house investigated in this study is located in Basrah, Iraq (Lat. 30° 34´N, Long. 47° 47´ E). The climate in Basrah is very hot in summer and fairly cold in winter . As a result a considerable amount of energy is consumed in both summer and winter season for cooling and heating residential building in order to bring the indoor temperature back to the comfort level (20ºC - 25ºC) [2]. The mean of daily maximum and minimum outside dry bulb temperatures for the months from June to September are in excess of 40ºC and 30ºC respectively [3]. The cooling season is thus long and extends over eight months of the year.

3. Energy Simulation

The transfer function method TFM [4] makes it possible to estimate the cooling load for a conditioned space on an hour-by-hour basis and to predict resultant conditions that can be expected in that space for various system types, control strategies, and operating schedules.

When a continuous function of time $f(t)$ is represented at a regular intervals Δt and its magnitudes are $f(0)$, $f(\Delta)$, $f(2\Delta)$, ….., $f(n\Delta)$ the Laplace transform is given as [5]:

$$\tau(z) = f(0) + f(\Delta)z^{-1} + f(2\Delta)z^{-2} + \ldots\ldots\ldots + f(n\Delta)z^{-n}$$

Where Δ = time interval , hour

Z = Z- transform variable that equal to $e^{s\Delta t}$

The preceding polynomial in z^{-n} is called the z – transform of the continuous function $f(t)$.

Because of the radiative component and the associated heat storage effect , the space sensible cooling load at time t can be related to the sensible heat gains and previous cooling loads in the form of a continuous function of time $f(t)$, which can be expressed as a z–transform.

Weighting factors are used to weight the importance of current and historical values of heat gain and cooling load on currently calculated cooling loads.
The calculation of space cooling load using the transfer function method consists of two steps. First, heat gains or heat loss from exterior walls, roofs, and floors are calculated and the solar and internal heat gains are calculated directly for the scheduled hour . Second, room transfer function coefficients or room weighting factors are used to convert the heat gains to cooling loads , or the heat losses to heating loads [5].
The transfer function method and transfer function coefficients can be expressed as follows [5]:

$$Q_{rs,t} = \sum_{i=1}^{i} (\nu_0 \, q_{rs,t} + \nu_1 \, q_{rs,t-\Delta} + \nu_2 \, q_{rs,t-2\Delta} + \cdots\cdots) - (\omega_1 \, Q_{rs,t-\Delta} + \omega_2 \, Q_{rs,t-2\Delta} + \cdots\cdots)$$

Where : i= number of heat gain components in the same group.
Δ = time interval .
t- nΔ = time at t- nΔ.
$q_{rs,t}$ = Space sensible heat gain having radiative or radiative and convective components.
$Q_{rs,t}$ = Space cooling load.
ν_o , ν_1, ν_2, ………, ω_1 , ω_2 , ………, are the weighting factors.

The Basra hourly city weather data [6] are used with the e-Quest program to carry out the analysis for this study. The e-Quest code has the ability to simulate a wide variety of potential energy conservation measures in buildings and it has been widely tested for accuracy.

4. The Average House (Base House)

The dimensions of the chosen house as shown in Fig. (1) are taken as the average of some 25 models of the one floor houses published by the ministry of housing and development taken from reference[7] and has been used by References [8], and [9] earlier.
The other characteristics of the Base House is shown in Table (1).
The characteristics of air conditioning system suggested to be used in the Base House are given in Table (2).
The assumed daily schedule for occupancy, lighting, and equipment are given in Table (3).

5. Test case 1 (Base- House)

The transfer function method TFM is used in the present study. The e-Quest program is used in the present study carry out the analysis. The thermal performances of the Base House are given in Fig. s (2 – 5). Fig. (2) shows that the total annual electric energy consumption is 26.95 MWh. It also shows that the percentage of annual electric energy consumption for cooling is 56% of the total annual electric energy consumption. Fig. (3) shows that the peak cooling load takes place at (28^{th} – July at 9 P.M). It is found that wall and roof conduction cooling load is 58 % of the total peak cooling load. Fig. (4) shows that the peak heating load for the base house take place at (30 – Dec. at 6 .A.M). It is also show the percentage of the wall and roof peak heating load components is 60% of the peak heating load while the infiltration is 31% of the total peak heating load. Fig. (5) show that the maximum monthly total cooling load for the base house took place at July and August which is equal to 6.9 ton.

6 Parameters of Building

6.1 Effect of Building Materials

6.1.1 Effect of Wall Building Materials

The thermal properties of building materials are taken from references [6,7,9,10,11,13]. Different types of wall materials effect is tested on the monthly space cool and heat energy consumption as shown in Fig. s (6 – 7) . It is found that using thermo-stone the annual space cool electric energy consumption is reduced from 15.2 MWh to 14.3 MWh, i.e. a save of 5.9 % of the annual space cool energy consumption compared to the base house table (4). Also it is found that the worst wall building materials is filled concrete block. Table (4) shows that if the base house wall building material is changed from 200 mm ordinary brick to 200 mm filed concrete block the annual space cool electric energy consumption is increased from 15.2 MWh to 15.77 MWh compared to the base house, i. e increase the annual space cool electric energy consumption by 3.75 % compared to the base house case. From Fig. (6) and table (4) it is found that if we increase the thickness of the ordinary brick wall building material from 200 mm to 300 mm the annual space cool electric energy consumption is reduced from 15.2 MWh (base case) to 14.71 MWh, i.e. a save of 3.2 % of the annual space cool electric energy consumption compared to the base house case. Fig. (7) show the monthly space heat electric energy consumption for different wall building materials. From Fig. (7) and table (4) it is found that the best wall building materials for heating season is the thermo-stone wall building material and by using thermo-stone wall it saves 12.4 % of the annual space heat compared to the base house case. From Fig. (7) and table (4) it is found that the worst wall building material for winter season is limestone and filled concrete block, by using limestone wall building material the annual space heat electric energy consumption is increased by 6.4 % compared to the base case, and by using filled concrete block wall building material the annual space heat electric energy consumption is increased by 6 % compared to the base case.
Then it is concluded that the best material to be used in walls of residential buildings in Basrah city is thermo-stone, while the worst building material to be used is the filled concrete block.

6.1.2 Effect of Roof Building Materials

The effect of changing roof building materials is shown in Fig. (8) and Table (5). Fig. (8) shows the monthly space cool electric energy consumption for different roof building material.
Case 1 in Fig. (8) represents the base house case. In Fig. (8) and table (5) it is found that if the thickness of roof sand layer is increased from 100 mm to 200 mm the annual space cool electric energy consumption is reduced from 15.2 MWh to 14.67 MWh, i.e 3.48 % saving when compared to the base case. Also if the roof building material is changed from concrete slab to brick roof with I

beam, the annual space cool electric energy consumption is nearly equal. While if thermostone is used with I beam the annual space cool electric energy consumption is reduced by 4.54 % compared to the base house case. From table (5) it is found that if the roof sand layer thickness is doubled the annual space heat electric energy consumption is reduced by 9.2 % compared to the base case house, and if the sand layer thickness is reduced to half the annual space heat electric energy consumption is increased by 6 % compared to the base case house. From tables (5) if the roof building material is changed from concrete slab to brick the annual space heat electric energy consumption is nearly identical. So it is concluded that the best roof configuration for the residential building in Basrah city is the thermo-stone roof with I beam. While the worst roof configuration is concrete slab with 50 mm sand layer.

6.2 Effect of Using Thermal Insulation

6.2.1 Effect of Wall Insulation types

The effect of wall insulation types is shown in Fig. (9). In this case different types of insulation material, of 50 mm thickness (polystyrene, polyurethan and polyisocyanurate) was used as inner wall insulation . It is found that the total annual electrical energy consumption approximately equal for all insulation types. We can conclude that changing insulation type have no effect on the total annual electric energy consumption.

6.2.2 Effect of Wall Insulation

The effect of using 50 mm polystyrene wall insulation and insulation position (inner, middle, outer) are shown in Fig. s (10 – 11) and table (6). Fig. s (10 -11) show the monthly space cool and heat electric energy consumption respectively for different wall insulation position. It is found that the inner wall insulation position is the best chose for cooling season, the annual space cool electric energy consumption is reduced from 15.2 MWh (base case house without insulation) to 12.8 MWh, i.e 15.79% saving, the annual space heat electric energy consumption is reduced from 2.5 MWh (base case house) to 1.91 MWh , i.e 23.6% saving. So it can be concluded that the best wall insulation position is the inner position ,for heating season.

6.2.3 Effect of Roof Insulation

The effect of using 50 mm polystyrene roof insulation and its position are shown in Fig. s (12 – 13) and table (7). From Fig. (12) and table (11) it is found that by using 50 mm inner polystyrene roof insulation the annual space cool electric energy consumption is reduced from 15.2 MWh (base house case) to 12.55 MWh, (17.4 % saving). Fig. (13) shows the monthly space heat electric energy consumption for different roof insulation position. It is found that by using middle roof insulation the annual space heat electric energy consumption is reduced by 18.8 % compared to the base house case. So it is concluded that the best roof insulation position is the inner insulation position as shown in table (7).

6.2.4 Effect of Total House Insulation

The effect of insulation on the total house using 50 mm polystyrene is shown in Fig. (14) and table (8). Fig. (14) shows the annual electric energy consumption for different total house insulation position. From Fig. (14) and table (8) it is found that by using inner total house insulation (wall + roof), the annual space cool electric energy consumption is reduced by 22.89 % compared to the base case house (without insulation), and the annual space heat electric energy consumption is reduced by 56.4 % . If we use outer total house insulation the annual space cool electric energy consumption is reduced by 22.5% , and the annual space heat electric energy consumption is reduced by 44.8 % . If we use middle total house insulation the annual space cool electric energy consumption is reduced by 23.09 % and the annual space heat electric energy consumption is reduced by 42.8 %. From Fig. (14) and table (8) it is found that the best case for cooling season is the middle total (wall + roof) house insulation, and the best case for heating season is the inner total (wall + roof) insulation.

7. The Optimum House Case

The characteristics of the optimum house are:- The external wall is thermo-stone with 50 mm inner polystyrene insulation and its wall exterior color is white . The roof is concrete slab with 200 mm sand layer, 50 mm inner polystyrene insulation and tiles. Roof exterior color is orange. The infiltration rate of the optimum house is 0.5 ACH, and the percentage of glazed area is (15% north and south , 2% east and west). Other characteristics of the optimum house are shown in table (9). The results of comparison between the optimum house case and the base house case is shown in table (10). The annual total electric energy consumption of the optimum house is reduced by 10.41 MWh (38.6% reduction). The annual space cool and heat electric energy consumption is reduced by 7.5 MWh (49.3% reduction) and 1.25 MWh (50% reduction) respectively. The annual fans electrical energy consumption is reduced by 1.9 MWh (59.5% reduction). The peak total cooling load is reduced from 18.88 kW (base house case) to 7.97 kW (optimum house case), i.e reduction by 57.8%, and the peak heating load is reduced from 7.52 kW to 2.71 kW, i.e reduction by 63.9% . The maximum monthly cooling load is reduced from 6.9 ton to 3.8 ton, i.e reduction by 44% compared to the base case house.

8. The Worst Case House

The characteristics of the worst house are:- The external wall is filled concrete block and its exterior wall color is dark. The roof is of concrete slab with 50 mm sand layer and tiles. Roof exterior color is gray . The infiltration rate of the worst house is 3 ACH. The percentage of glazed area of the worst house is (2% north and south , 15% east and west). Other characteristics of the worst house are shown in table (11). The results of comparison between the worst house case and the base house case is shown in table (12). The annual total electric energy consumption of the worst house is increased by 7.8 MWh (28.9 % increase compared with the base house case). The annual space cool and heat electric energy consumption are increased by 4.54 MWh (29.8 % increase) and 1.29 MWh (51.6% increase) respectively. The annual fans electrical energy consumption is increased by 1.72 MWh (53.9 % increase).

9. Standardizing the Annual Electric Energy Consumption for a Residential Building in Basrah City

The total annual electric energy for the optimum house case equal to 16.54 MWh and when it divided by the total building area (156m2), the annual electric energy consumption per unit area equals to 106 kWh/m2 . The total annual electric energy consumption for the worst house case equal to 34.74 MWh and the annual total electric energy consumption per unit area equal to 222 kWh/m^2. The annual total electric energy consumption per unit area for the base house case is equal to 173 kWh/m^2.

To make a scale for annual electric energy consumption per unit area the difference between annual total electric energy consumption per unit area for the worst house case ($E_{t\ worst}$) and the optimum house case ($E_{t\ optimum}$).

$\Delta E = E_{t\ worst} - E_{t\ optimum}$

$\Delta E = 222 - 106 = 116$.

The division of a scale of ten for the annual electrical consumption per unit area in Basrah city equal to

Each scale = $\frac{116}{10}$ = 11.6 kWh/m^2.

The optimum house case as scale No. 0 , and the worst case house as scale No. 10 . The scales is shown in Fig. 15. In this scale the base house case take scale No. 5.7 . This scale helps the designers and owners of a residential building in Basrah city to improve the design of their houses to consume economical energy

10. Study of Real House Located at Basrah City According to the standard

A real house located in Basrah city is studied. and drawn in Autocad , then it imported to the eQuest building energy simulation program. The calculated total annual electric energy consumption per square meter found equal to (192.7 kWh/m^2). By applying the standardized method it was found that the house has a scale of 7.74 this case considered as the base case for real house study.

11. Modifications to Reduce the Electric Energy Consumption for the Real Case Study House

The exterior wall color of this house is changed from gray to white , and orange color is added to exterior roof tiles, the scale of the annual electric energy consumption is reduced from 7.47 to 6, and this represent as first improvement. If 5 cm polystyrene insulation added to the inner walls and roofs the scale of the annual electric energy consumption is reduced from 7.47 to 4.25, and this represent the second improvement as.

12. Conclusions

[1] The work discussed in this research has shown clearly that it is possible to go a long way towards improving the thermal performance of a residential building in Basrah city which some concluded points can be abbreviated in the following points.

[2] The best wall building materials is thermo-stone and by using thermo-stone we can reduce the annual cooling energy consumption by 5.9%, and reduce the annual heating energy consumption by 12.4%.

[3] The worst wall building material is filled concrete block, by using concrete block the annual cooling energy consumption is increased by 3.7%, and the annual heating energy consumption is increased by 6%.

[4] If the roof sand layer is increased from 100 mm to 200 mm the annual cooling energy consumption is reduced by 3.4%, and the annual heating energy consumption is reduced by 9.2%.

[5] The use of thermal insulation is an important factor, if 50 mm inner wall polystyrene insulation used the annual cooling energy consumption is reduced by 15.7%, and the annual heating energy consumption is reduced by 23.6%.

[6] If 50 mm inner polystyrene roof insulation used the annual cooling energy consumption is reduced by 17.4%, and the annual heating energy consumption is reduced by 23.2%.

[7] If 50 mm middle polystyrene total house insulation used the annual cooling energy consumption is reduced by 23%, and the annual heating energy consumption is reduced by 42.8%.

13. References

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Table 1: Characteristics of the Base House

Characteristics	Description
Location	Basra (Lat. 30° 34´N , Long. 47° 47´ E)
Orientation	Front elevation facing the North
Plane shape	Square
Number of stories	1
Height	3 m
Type of glass	Ordinary type , single pane 6mm thick, without indoor shading
External shading device	None
Wall exterior color	dark
External walls	15 mm cement plaster outside + 200 mm ordinary brick + 15 mm gypsum plaster inside
Roof	25 mm tiles outside + 100 mm sand + 10 mm asphalt + 210 mm concrete slab + 15 mm gypsum plaster inside
Floor	25 mm tiles + 37 mm low weight concrete + 240 mm sand
People living in it	8
Lighting	1 kWe
Appliances	2 kWe
Infiltration	1 Air change per hour

Table 2 : The air conditioning system Characteristics of the Base House.

Characteristics	Description
System type	Constant – volume DX Air – cooled A/C system with Electric Heating
Thermostat type	Two – position with dual (heating and cooling) set point
Thermostat setting	25 °C for cooling and 20 °C for heating
COP	2.9
Ventilation	None
Heating and Cooling	Available all over the year

Table 3 : Schedules of occupancy and operation of the typical house.

Time (hour)	Occupancy Fraction %	Lighting Fraction %	Equipment Fraction %
1	100	5	5
2	100	5	5
3	100	5	5
4	100	5	5
5	100	5	5
6	100	5	5
7	100	30	50
8	50	10	30
9	50	10	30
10	50	10	30
11	50	10	30
12	50	10	30
13	100	10	30
14	50	10	30
15	50	10	30
16	50	10	30
17	100	10	30
18	100	90	60
19	100	90	60
20	80	70	60
21	80	70	5
22	80	70	5
23	100	5	5
24	100	5	5

Table 4 : Effect of wall building material on annual electric energy consumption.

Case No.	Wall description	Annual electric energy % Save Cooling	Annual electric energy % Save Heating	Annual electric energy % Save Total
1	15 cement plaster + 200 ordinary brick + 15 gypsum plaster	0	0	0
2	15 cement plaster + 300 ordinary brick + 15 gypsum plaster	3.2	5.6	3.55
3	15 cement plaster + 200 thermostone + 15 gypsum plaster	5.9	12.4	6.83
4	15 cement plaster + 200 limestone + 15 gypsum plaster	- 3.4	- 6.4	-3.84
5	15 cement plaster + 200 hollow concrete block + 15 gypsum plaster	- 3.68	- 1.6	-3.38
6	15 cement plaster + 200 filled concrete block + 15 gypsum plaster	- 3.75	-6	-4.06

Notes:
1- all dimension in mm.
2- materials arranged from outside to inside .
3- the line under words show the wall change from the base house wall.

Table 5 : Effect of roof building material on annual electric energy consumption .

Case No.	Roof Description	Annual electric energy % save cooling	Annual electric energy % save heating	Annual electric energy % Save Total
1 (Base house)	25 tile + 100 sand + 10 asphalt + 210 concreate slab + 15 gypsum plaster	0	0	0
2	25 tile + 200 sand + 10 asphalt + 210 concreate slab + 15 gypsum plaster	3.48	9.2	4.29
3	25 tile + 100 sand + 10 asphalt + 100 brick + 15 gypsum plaster	0.13	-0.4	0.05
4	25 tile + 50 sand + 10 asphalt + 210 concreate slab + 15 gypsum plaster	-5.46	-6	-5.53
5	25 tile + 100 sand + 10 asphalt + 100 thermostone + 15 gypsum plaster	4.54	6.4	4.8

Notes:-
1- all dimension in mm.
2- material arranged from outside to inside .
3- the line under words show the roof change from the base case roof .

Table 6 : Effect of wall insulation on annual electric energy consumption

Case No.	Description	Annual % save cooling	Annual % save heating	Annual % Save Total
1	Without insulation	0	0	0
2	(5cm)inner polystyrene insulation	15.79	23.6	16.89
3	(5cm)outer polystyrene insulation	7.63	20.8	9.49
4	(5cm)middle polystyrene insulation	9.6	20.4	11.12

Table 7: Effect of roof insulation on annual electric energy consumption.

Case No.	Description	Annual % save cooling	Annual % save heating	Annual % Save Total
1	**Base roof (without insulation)**	**0**	**0**	**0**
2	**(5 cm) inner polystyrene roof insulation**	**17.4**	**23.2**	**18.24**
3	**(5 cm) outer polystyrene roof insulation**	**10.26**	**20.4**	**11.69**
4	**(5 cm) middle polystyrene roof insulation**	**10.59**	**18.8**	**11.75**

Table 8 : Effect of total house insulation on annual electric energy consumption.

Case No.	Description	Annual % save cooling	Annual % save heating	Annual % Save Total
1 (base house)	Base house without insulation	0	0	0
2	(5 cm) inner polystyrene (wall + roof) insulation	22.89	56.4	27.62
3	(5 cm) outter polystyrene (wall + roof) insulation	22.5	44.8	25.7
4	(5 cm) middle polystyrene (wall + roof) insulation	23.09	42.8	25.7

Table 9 : Characteristics of the optimum case house.

Characteristics	Description
Location	Basrah (Lat. 30° 34´N , Long. 47° 47´ E)
Orientation	Front elevation facing the North
Plane shape	Square
Number of stories	1
Total height	3 m
Type of glass	Ordinary type , single pane 6mm thick, without indoor shading
Glazing distribution	15 % North and South, 2% East and West
Window external shading device	South window 10% full shading , north window 30% full shading, east and west window without shading
External walls	15 mm cement plaster outside + 200 mm thermostone + 50 mm polystyrene insulation
Wall exterior color	White
Roof	25 mm tiles outside + 200 mm sand + 10 mm asphalt + 210 mm concrete slab + 50 mm polystyrene insulation
Roof exterior tiles color	Orange
Floor	25 mm tiles + 37 low weight concrete + 240 mm sand
People	8
Lighting	1 kWe
Appliances	2 kWe
Infiltration	0.5 Air change per hour
Schedules for people, equipment, and lights	Same as base house case

Table 10 : Comparison between base case and optimum case.

	Annual Space cool (MWh)	Annual Space heat (MWh)	Annual Fans (MWh)	Annual Misc. equipment (MWh)	Annual lights (MWh)	Annual total electric (MWh)
Base case	15.2	2.5	3.19	4.23	1.8	26.95
Optimum case	7.7	1.25	1.29	4.23	1.8	16.54
% Saving	49.34	50	59.56	0	0	38.627

Table 11 : Characteristics of the worst case house.

Characteristics	Description
Plane shape	Rectangular
Length	17.6 m
Width	8.8 m
Aspect Ratio	0.5
Number of stories	1
Total height	3 m
Type of glass	Ordinary type , single pane 6mm thick, without indoor shading
Glazing distribution	15 % East ,West, and South. 2% North
Window external shading device	None
External walls	15 mm cement plaster outside + 200 mm filled concrete block + 15 mm gypsum plaster inside
Wall exterior color	Dark
Roof	25 mm tiles outside + 50 mm sand +10 mm asphalt + 210 mm concrete slab + 15 mm gypsum plaster inside
Roof exterior tiles color	Gray
Floor	25 mm tiles + 37 mm low weight concrete + 240 mm sand
People	8
Lighting	1 kWe
Appliances	2 kWe
Infiltration	3 Air change per hour
Schedules for people, equipment, and lights	Same as base house case

Table 12: Comparison between base house case and worst house case.

	Annual Space cool (MWh)	**Annual Space heat (MWh)**	**Annual Fans (MWh)**	**Annual Misc. equipment (MWh)**	**Annual lights (MWh)**	**Annual total electric (MWh)**
Base case	15.2	2.5	3.19	4.23	1.8	26.95
Worst case	19.74	3.79	4.91	4.23	1.8	34.75
% Increase	29.8	51.6	53.9	0	0	28.9

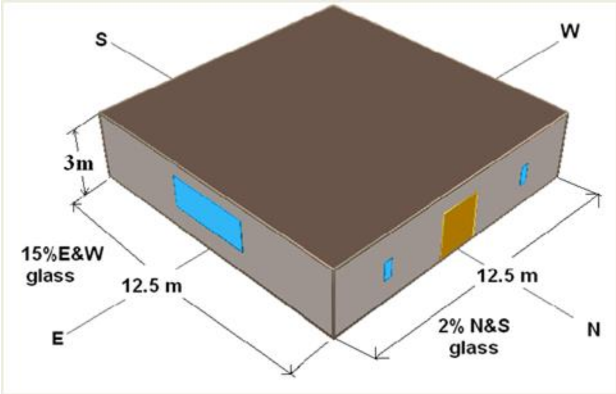

Fig. 1 The Base House with average length of partition wall equal (33m).

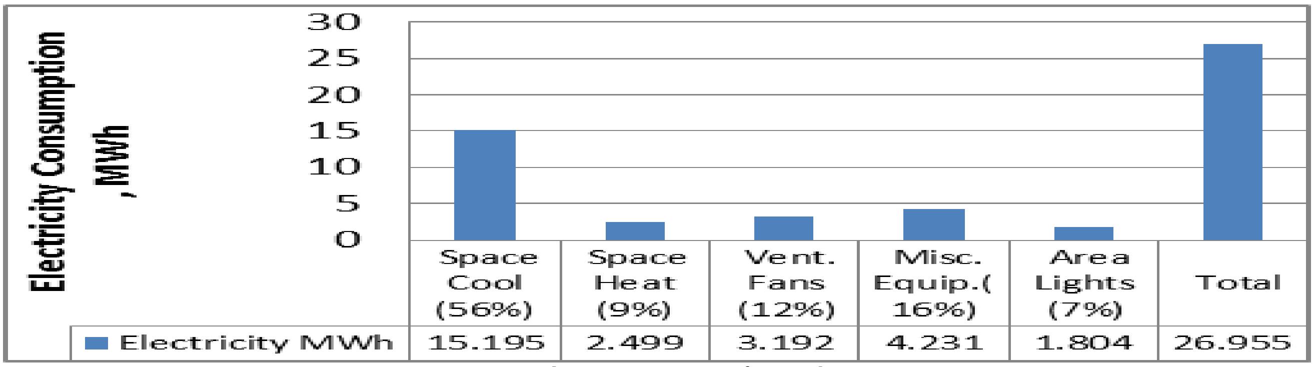

Fig. 2 Annual energy consumption for Base house.

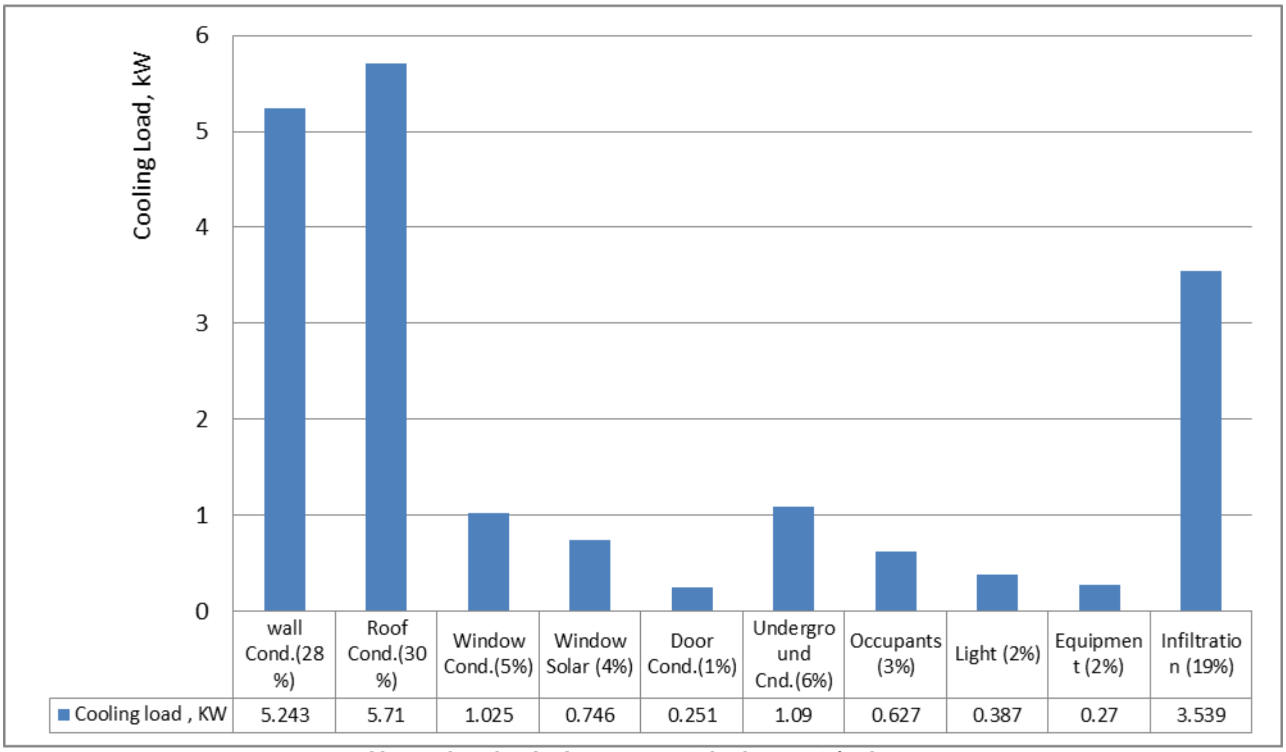

Fig. 3 Building peak cooling load components (Jul28th at 9PM) for the Base House.

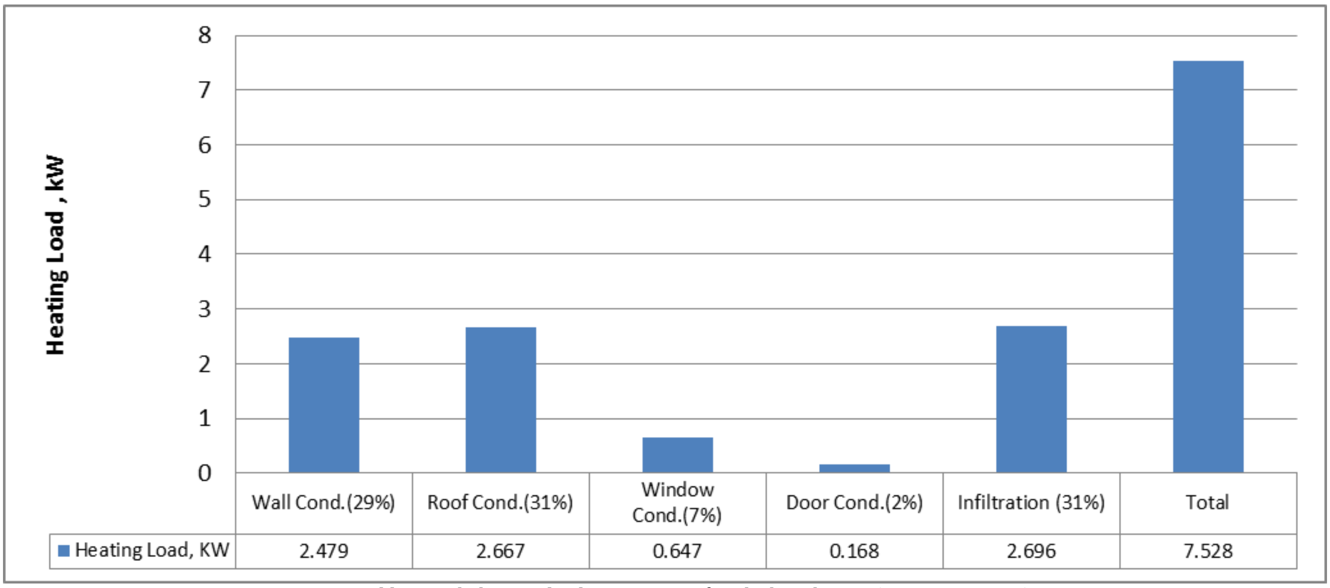

Fig. 4 Building peak heating load components for the base house (Dec 30 6AM).

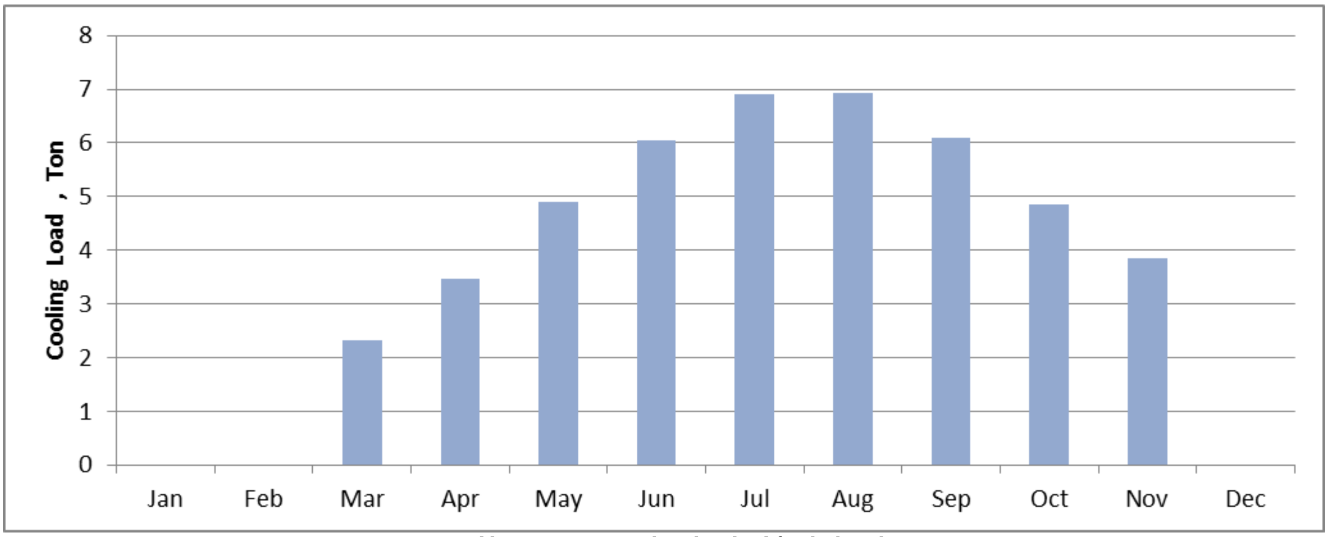

Fig. 5 Building maximum total cooling load for the base house.

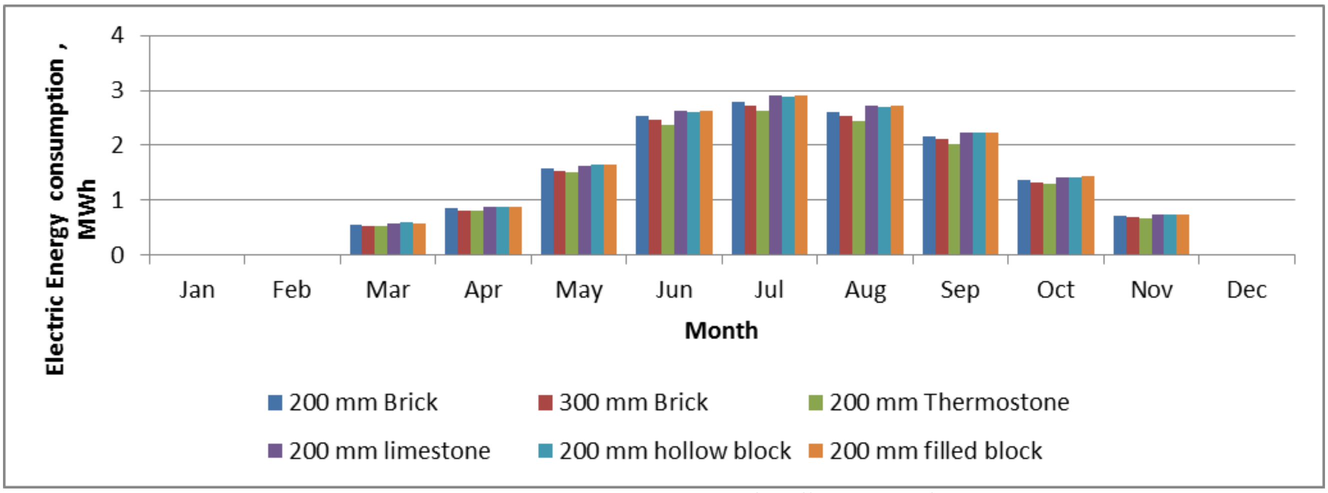

Fig. 6 Monthly space cool - electric energy consumption for different types of walls material.

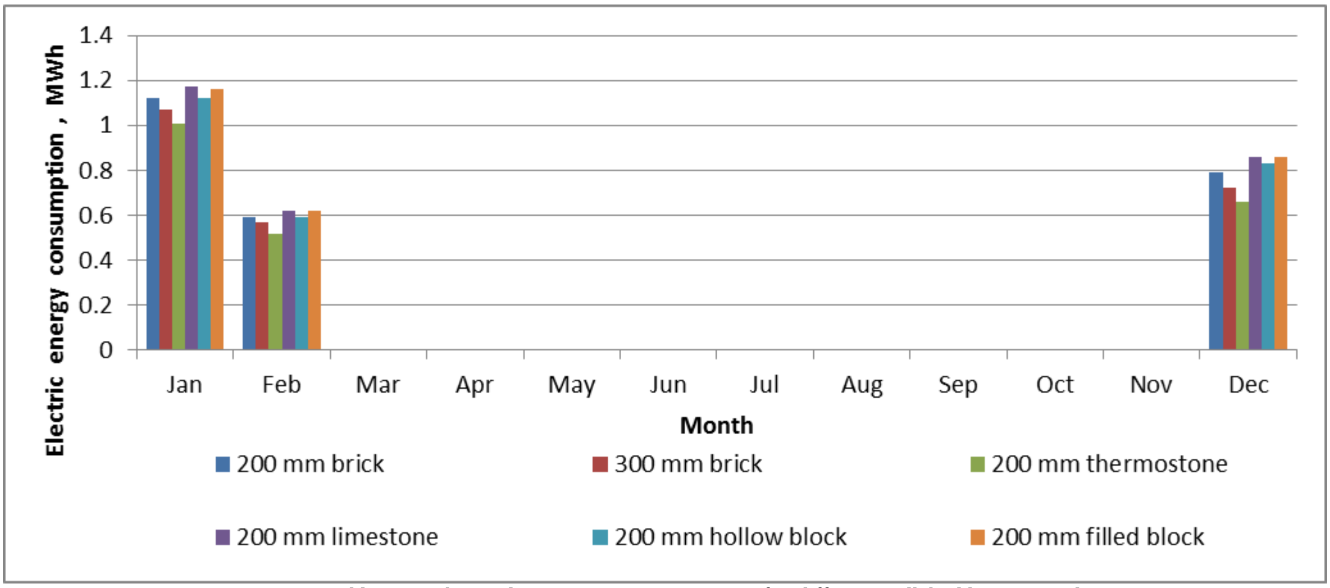

Fig. 7 Monthly space heat - electric energy consumption for different wall building material

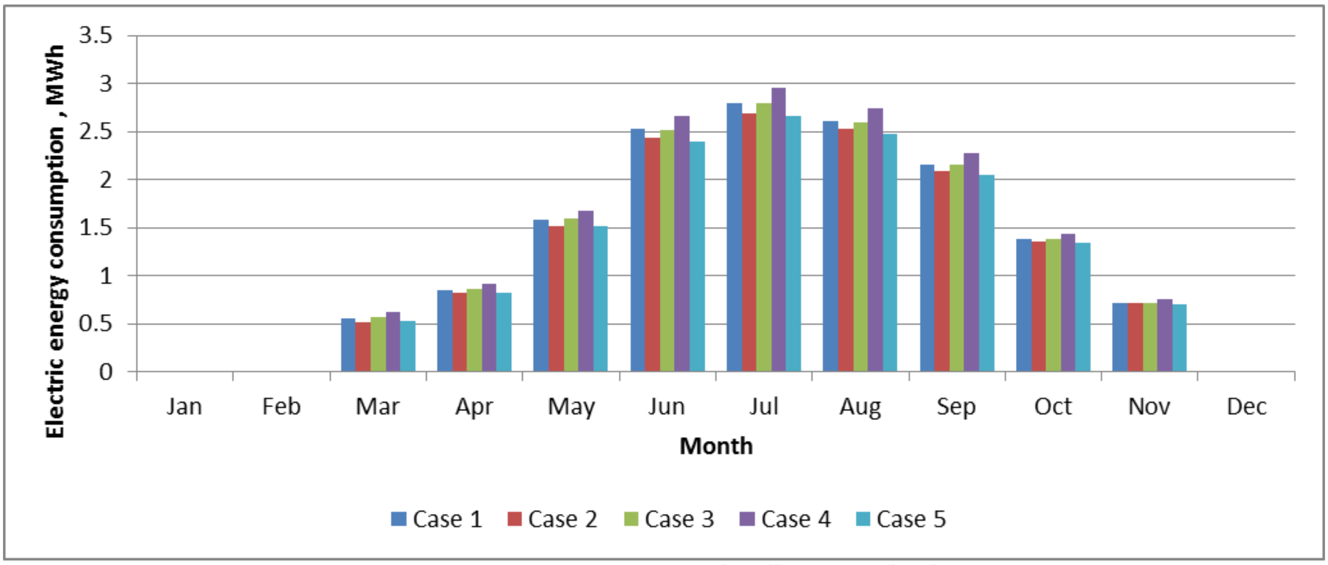

Fig. 8 Monthly space cool- electric energy consumption for different types of roof building material.

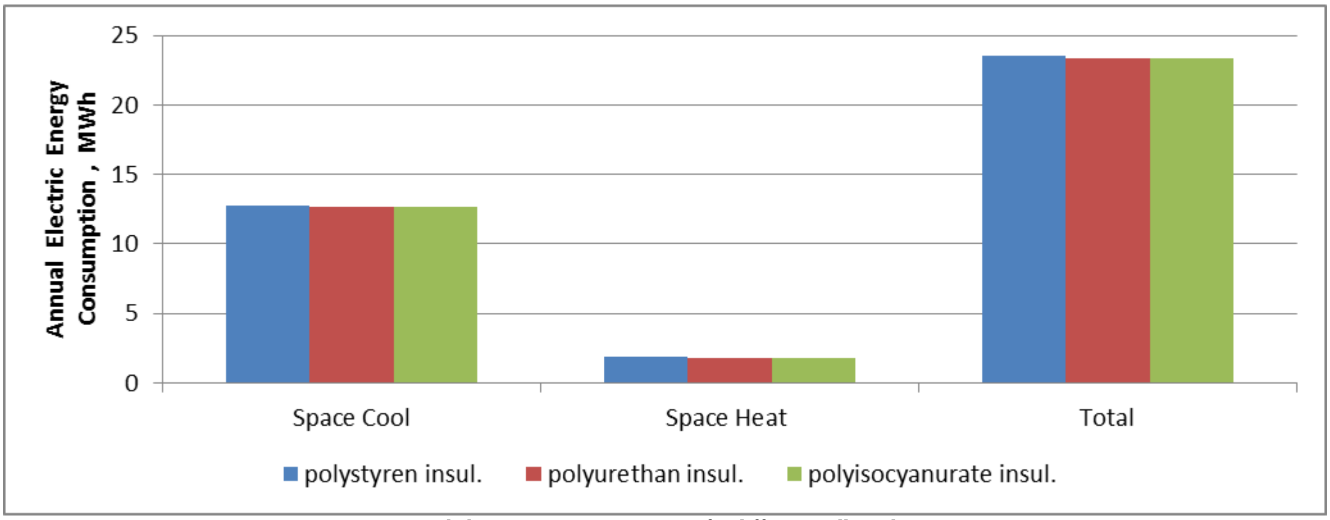

Fig. 9 Annual electric energy consumption for different wall insulation types.

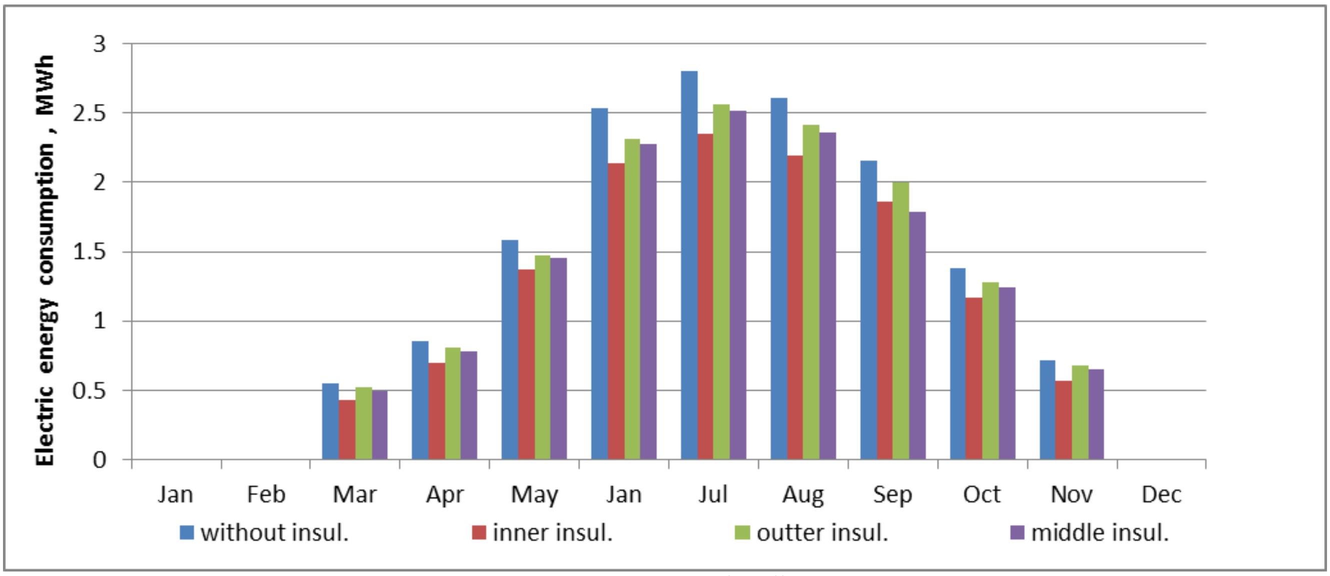

Fig. 10 Monthly space cool - energy consumption for different wall insulation position.

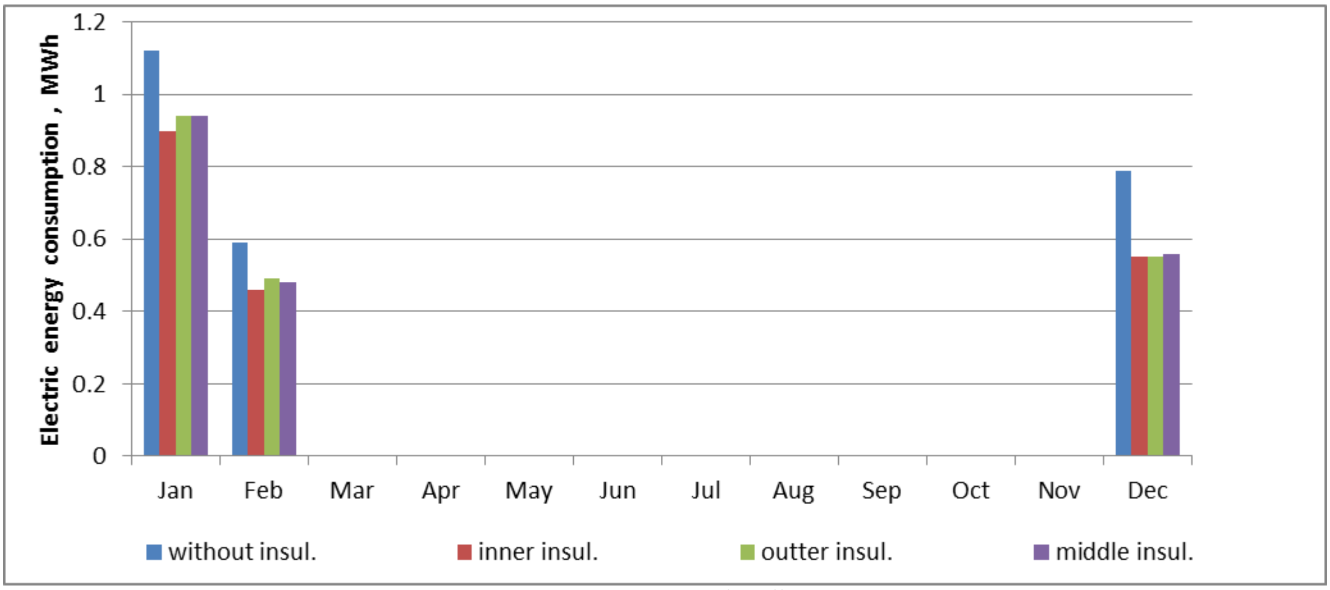

Fig. 11 Monthly space heat - energy consumption for different wall insulation position.

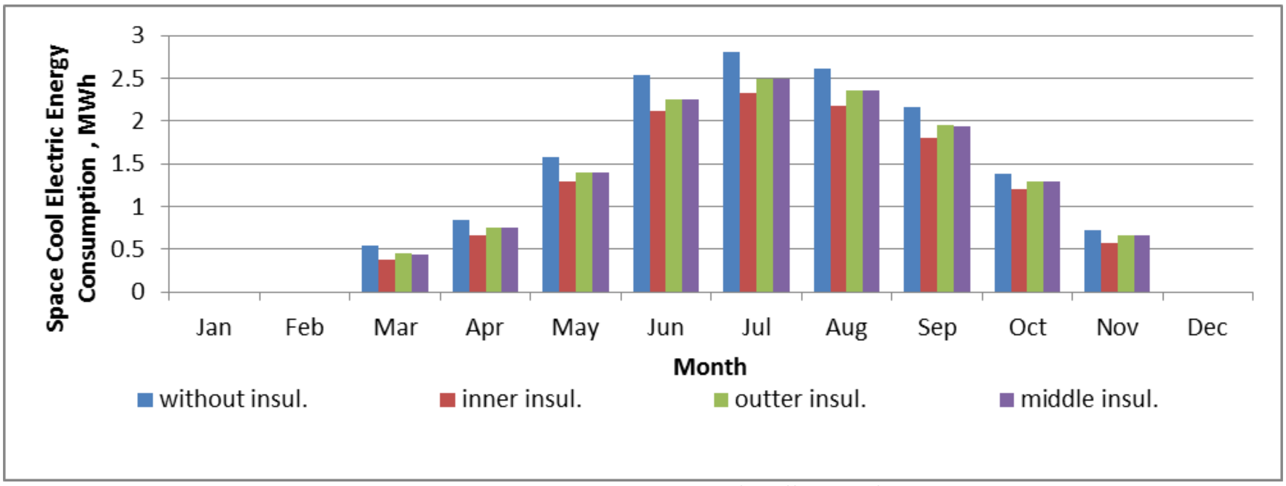

Fig. 12 Monthly space cool - electric energy consumption for different roof insulation position.

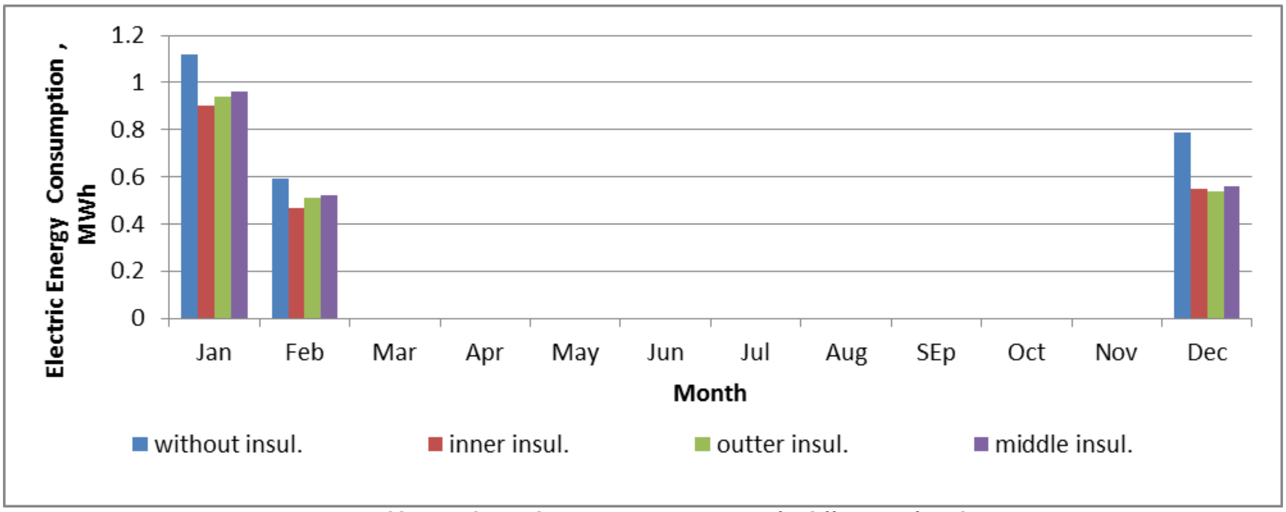

Fig. 13 Monthly space heat - electric energy consumption for different roof insulation

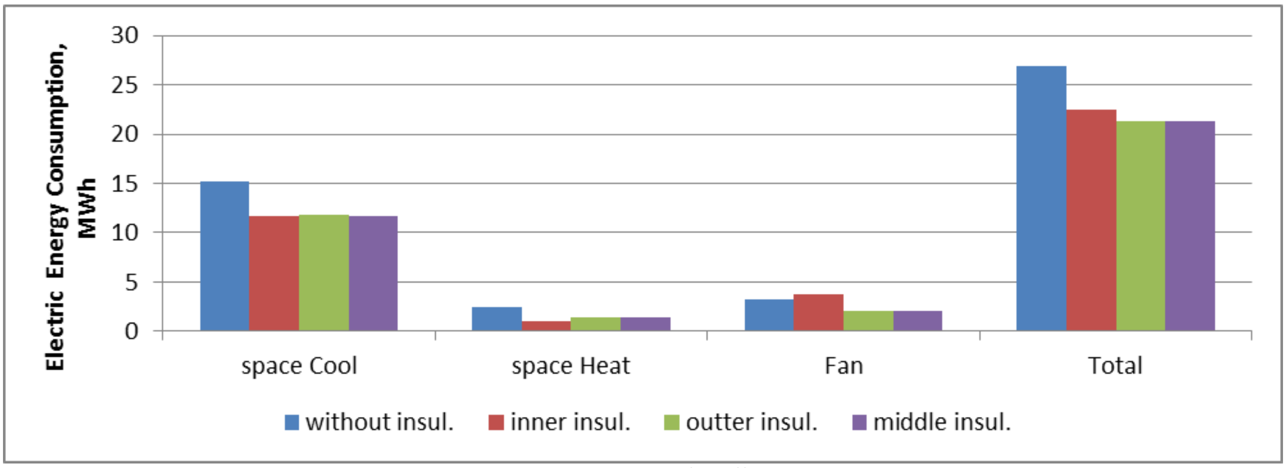

Fig. 14 Annual electric energy consumption for different total house insulation.

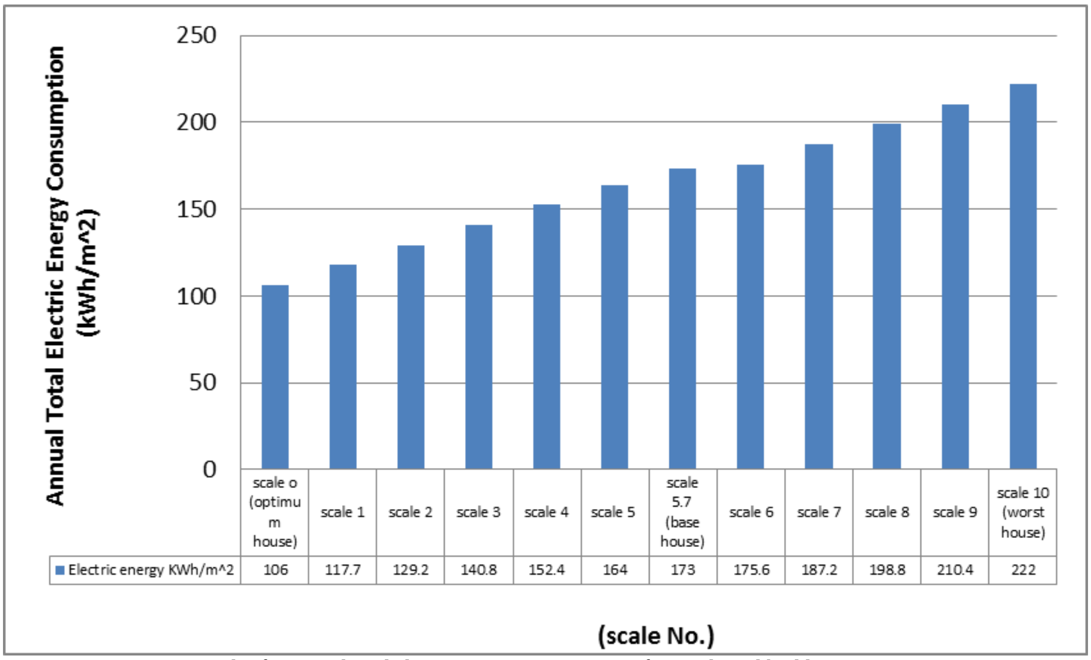

Fig. 15 Scales for annual total electric energy consumption for residential building in Basra city.