International Journal Of Architecture and Urban Development
Vol.1, No.3, Winter 2012

Evaluating Built Area and Occupant Number Impact on Winter Gas Consumption- A Case in Shiraz Urban Residence Sector

[1]Zahra Barzegar; [2]Nooshin Karimi; [3]Mohammad Ali Nemati*

[1]Ph. D., Candidate Department of Art & Architecture, Science And Research Branch, Islamic Azad University, Tehran, Iran
[2]Ph. D.,Department of Architecture, Shahr_e_Ray Branch, Islamic Azad University, Tehran, Iran
[3]Department of Architecture, Beyza Branch, Islamic Azad University, Beyza, Iran.
Shiraz, Iran

Recieved 02.07.2011; Accepted 10.12.2011

ABSTRACT: The purpose of this research is to found the impact of built area and occupant number on winter gas consumption in the residential building sector of Iran, Shiraz.Sothe annually and monthly gas consumption data through 19 houses were analyzed to achieve the heating energy consumption and operation month.The average operation months of gas heating consumption were from first of November up to end of April and the average maximum monthly gas consumption of sample houses was in February. On the other hand, the case study houses have different built area from 80 t0 200 m2andoccupant number from 3 to 7 persons.It was concluded that the biggest and busiest houses did not consume the maximum annual gas consumption and so the smallest and low occupant ones about minimum consumption. Therefore, the samples heating consumption was not so related to the built area and occupant number. The occupant culture and behavior was more supposed to be related with energy consumption in residential sector of the city.

Keywords: *energy consumption, heating gas consumption, residential sector, built area, occupant number*

INTRODUCTION

Like all countries, Iranproducea high range of greenhouse gas emission due to its energy consumption, On top of the list figures CO2. A major emission source for CO2 is burning fossil fuels. As the residential sector accounts a large proportion of the country's annual energy consumption and as this consumption mainly concerns fossil fuels, it has an equally important share in the CO2 release. Hence, at first sight, the best policy for a decrease is by improving the energy efficiency (Hens et. al, 2001).

Supporting the lifestyles of the populations of modern cities requires vast quantities of natural resources and leads to environmental stresses such as air and water pollution. One important physical indicator is energy use. Many studies on cities consider direct or end-user energy consumption like residential ones (Lenzen et. al, 2004). Residential energy consumption and its variance lay on the integration of many factors, such as the floor area, materials of window frames, the number of family members, operation months of space heaters in winter and air conditioners in summer, and energy-saving actions. The residential samples Effective characteristics on energy consumption were divided to three kinds: building construction, occupant specifications, and society specifications. The first type samples could be window to wall ratio, step no, built area, envelope thermal transfer value, length to width ratio, building orientation and longevity. The occupant specifications were as consumer behavior, occupant number, the society specification included the government policy, energy prices and society culture. BA and occupant number specifications were considered to have substantial influence on heating need. Yeoet. al foundseveral energy saving methods which one of them was reducing the total floor heating area (Yeo et. al, 2003).Yohanis et. al found a clear correlation between average annual electricity consumption and floorareafor 27 representative dwellings in Northern Ireland.The number of family members, their ages and the amount of time they spend at home are detected as important factors in house energy consumption(Lucas et. al, 2001).

Shiraz is located in south of Iran in an arid and semi-arid region. Shiraz population in 2006 was 1,351,181 (General census 1956, 2006). Due to urban land, residential sector and population growths in last decades, the consumption of energy (electricity,

*Corresponding Author Email: n.karimi@srbiau.ac.ir

International Journal Of Architecture and Urban Development
Vol.1, No.3, Winter 2012

Nomenclature	
BA	Built area
Occ	Occupant number
E primary	Primary energy consumption
E cooling	Cooling energy consumption
E heating	Heating energy consumption
E Lighting	Lighting energy consumption
E Equip.	Equipments energy consumption

gas, etc.) and air pollution increased. This was resulted energy crisis in production, distribution and consumption sector and also the fossil fuel disadvantages dispersion for humankind as the air pollutant, climate change, ozone depletion and greenhouse gas emission (GHG).Therefore, there is an urgent need to develop an econometric model for energy intensity and GHG emission intensity in view of the poor energy endowment and environmental situation in Shiraz.In this paper, the built area (BA) and occupant number (Occ) impact on winter gas consumption in Shiraz urban residence sector was evaluated.

MATERIALS AND METHODS

Phases and methods

This study involved experimental and analytical activities divided into these phases:

- Selecting residential buildings data;
- Investigating sample characteristics as built area (BA) and occupant number (Occ);
- Collecting gas consumption annually, seasonally and monthly;
- Calculating heating energy consumption ($E_{heating}$) of the buildings;
- Analyzing Parametric of E heating operation months, in order to assess the heating load period;
- Analyzing Parametric of annual and monthly gas consumption, in order to assess the effect of BA and Occ on annually and monthly gas consumption;

For the process, different statistical and experimental methods are used.About measuring procedures, some points should be mentioned:

-Both electricity and natural gas consumptions had four different type consumption, including:

$$E_{Cooling} + E_{Heating} + E_{Lighting} + E_{Equip.} = E_{Total} = E_{Primary}$$

- Cooling energy consumption ($E_{Cooling}$) of the proposed case studies derives only from electricity, as the sample houses were not equipped with gas-cooling devices.
- Because of not using any electrical thermal equipment, heating energy consumption ($E_{Heating}$) of the proposed case studies derives only from natural gas.
- As mentioned before, the purpose of this study is to investigate the effect of BA and Occ on annual and monthly gas consumption; Thus, in this survey, $E_{Lighting}$ and E_{Equip}. have been supposed fixed, and $E_{Cooling}$ is from electricity energy that was not under the scope of this article, so $E_{Heating}$ would be measured as follows:

$E_{Natural\ gas}$: Summer: $E_{Natural\ gas} = E_{Cooling} + Cons. = 0 + Cons. = Cons.$

Winter: $E_{Natural\ gas} = E_{Heating} + Cons.$

Then: $E_{N.G} = E_{Heating}$

- Depend upon the sample houses behaviors, operation months of space heating in winter (low temperature months) was different periods.

Case study- Shiraz

Shiraz is located in the Shiraz Plain, south of Iran (29° 33` - 29° 41` N, 52° 29`- 52° 36` E, 1488 m above mean sea level). Shiraz, with the mean annual precipitation 320 mm, is located in an arid and semi-arid region. Shiraz population in 1956 was 170,659 and in 2006 was 1,351,181 and it is grown 7.92 fold during the period 1956-2006 (General census 1956, 2006) which is because of normal population growth and also immigration ratio to city. War, drought, and adoption and implementation of urban land law were the causes of immigration to Shiraz (Karimi et. al., 2009).

Due to urban land, residential sector and population growths in

Table 1: Shiraz electricity consumption from 1968 to 2006

Year	residential	total	Consumption growth	GHG emission
unit	Mwh	Mwh	Fold based on 1968	per capita
1968	-	52299	-	0.193797
1976	81774	348831	6.67	0.819212
1989	345682	850842	16.27	1.017687
1996	546001	1501543	28.71	1.456403
2006	1239721	3640064	69.60	2.965837

Data source: Power Distribution Company in Shiraz

the period of 1956-2006 the consumption of energy (electricity, gas, etc.) and air pollution increased. In addition, the average annually Iranian residential sector energy consumption per square meter was 310 KWh in 2006, while, for the same climate regions in the world was 120 Kwh. Therefore, Iranian residential sector energy consumption was 2.5 fold of the world (Toloeyan, 2006).

Due to Shiraz electricity consumption from 1968 to 2006, the consumption growth was 69.60 fold (based on the Power Distribution Company in Shiraz data). Moreover, the growth rate of Shiraz electricity consumption per capita from 1968 to 2006 was 15.30384 fold (Table 1). With little hope of a short-run solution to the problem, a long-term view needs to begin by acquiring a comprehensive knowledge of the energy consumption behavior of the household sector as an input into a more wide ranging energy plan for the city.

Materials- Residential energy consumption

In this research, two major effective factors on residential energy consumption, i.e. house characteristics, and energy consuming part were studied in the presented samples. Separately, the case studies were evaluated depends on mentioned characters to achieve the research scope.

Due to residential sector extension and consumption in Shiraz (one of big cities of Iran), 19 houses selected randomly between accessible ones. The needed characters were collected and categorized. As stated in table 2, each of houses owned specific BA and Occ.

According to Shiraz energy portfolio which divided into electricity and gas, to evaluate gas energy consumption in the case studies, it classified into heating (E Heating) and equipments (E Equip), which main gas consumption is for heating in cold season. In selected houses, the primary and common heating system is gas heater. Due to various houses characters, each of houses had specific annual gas consumption. The maximum annual gas consumption was related to H11 which is 3.81 km3and the minimum is related to H8 which is 1.04 km3. (Table 3)

Table 2: samples characters

Gas consumption	unit	H_1	H_2	H_3	H_4	H_5	H_6	H_7	H_8	H_9	H_{10}	H_{11}	H_{12}	H_{13}	H_{14}	H_{15}	H_{16}	H_{17}	H_{18}	H_{19}
Occ	person	5	4	5	5	5	3	5	5	5	4	4	5	5	4	5	4	4	7	5
BA	m^2	90	80	108	176	125	126	170	200	151	123	129	123	123	121	171	152	134	133	118

Table 3: samples annual gas consumption

Gas consumption	unit	H_1	H_2	H_3	H_4	H_5	H_6	H_7	H_8	H_9	H_{10}	H_{11}	H_{12}	H_{13}	H_{14}	H_{15}	H_{16}	H_{17}	H_{18}	H_{19}
Annual	$K M^3$	3.2	1.3	1.7	1.6	2.7	1.7	1.21	1.04	1.24	2.56	3.81	2.01	1.68	1.88	1.2	2.92	2.01	2.09	2.09

Table 4: samples heating operation months

(Thepal gray cells related to heating load months and the dark ones was for maximum one)

season	Month	H_1	H_2	H_3	H_4	H_5	H_6	H_7	H_8	H_9	H_{10}	H_{11}	H_{12}	H_{13}	H_{14}	H_{15}	H_{16}	H_{17}	H_{18}	H_{19}
Summer	July																			
	August																			
	September																			
Autumn	October																			
	November																			
	December																			
Winter	January	625						243.3			490	799	300			243.3	650	300	384.9	407
	February		230	350	296	490	350	243.3	272.7	380				355.8	377	243.3				
	March																			
Spring	April																			
	May																			
	June																			

International Journal Of Architecture and Urban Development
Vol.1, No.3, Winter 2012

Results

Gas operation months

In samples, extended operation months was from October to April, but each house was started its heating in different months from October to January, and ended it from March to April. Table 4 indicated the individual gas operation months of samples graphically.

Minimum and maximum average monthly gas consumption

If the average gas consumption of the samples was considered, the data could be more confident. The average gas consumption change was from first of November up to end of April, so the average operation months of gas heating consumption were in the mentioned period (Table 5). This was shown shiraz heating need zone which depend on its heating energy type, need to natural gas in heating operation months is more.

The average maximum monthly gas consumptionof sample houses was in February which is the middle of winter zone. Therefore February was the coldest one with high heating load. For fossil fuel replacement with renewable ones, in designing renewable devices the highest heating need is important.

BA and annual gas consumption

As a rule gas consumption is affected by each meter of BA, because an extra heating load needs for each meter extension. For investigating the role of BA in increasing or decreasing gas consumption in urban residences, firstly case studies were evaluated and the conclusions were generalized. The case studies houses have different built space from 80 t0 200 m^2. From BA and annual gas consumption charts, it is resulted that:

- The maximum gas consumption was related to H11 and the minimum one was for H8. (Fig. 1)
- The highest BA belonged to H8 and the lowest one belonged to H2. (Fig. 1)
- The biggest house did not consume the maximum annual gas consumption and so the smallest one about minimum consumption. (Fig. 2)
- The slope of BA and annual gas consumption charts were

Table 5: samples average monthly gas consumption
(The pal gray cells related to heating load months and the dark ones was for maximum one)

Month	unit	Average monthly gasconsumption
July	M^3	61.07
August	M^3	61.9
September	M^3	66.48
October	M^3	95.72
November	M^3	156.85
December	M^3	270.69
January	M^3	362.07
February	M^3	365.64
March	M^3	278.86
April	M^3	128.45
May	M^3	85.41
June	M^3	67.58
Annual	K M^3	5.56

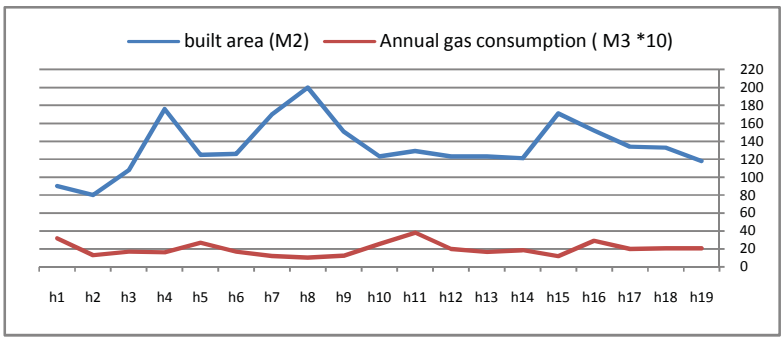

Fig. 1: comparison of samples BA and annual gas consumption

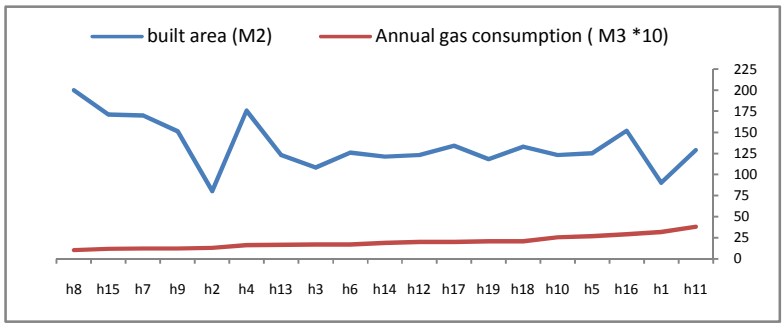

Fig. 2: comparison of samples BA and ranked annual gas consumption

not the same, and completely differed. The slop of these two chartsis considered to be to some extend opposite. (Fig. 2)
- The local maximum points of each chart were not in same houses. (Fig. 1)

Occand annual gas consumption

Warm water, equipments and other energy needs of each person causes a per capita energy usage. But if a number of persons leave together, it comes to mind that consumption is increased. In this article, the houses Occ differed from 3 to 7 persons. Due to Occ and annual gas consumption charts, it was stated that:
- The highest consumption was related to H11 and the lowest one was for H8. (Fig. 3)
- The maximum Occ belonged to H19 and the minimum one belonged to H6. (Fig. 3)
- The maximum energy consumption was not for the busiest house and so the minimum one.
- The slope of Occ chart and Ec chart were not the same, and completely differed. (Fig. 4)
- The local maximum points of each chart were not in same houses. (Fig. 3)
- Although the couple houses like H3 and H6 had the same annual gas consumption (both17.1), but the Occ of them were various(5 and 3 Persons, Respectively).

CONCLUSION

As the residential sector accounts a large proportion of the Iran annual energy consumption and as this consumption mainly

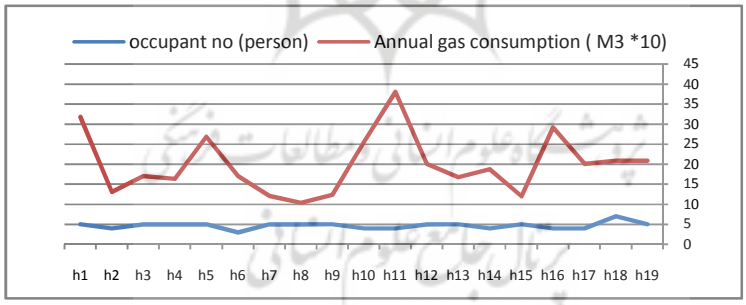

Fig. 3: comparison of samples Occ and annual gas consumption

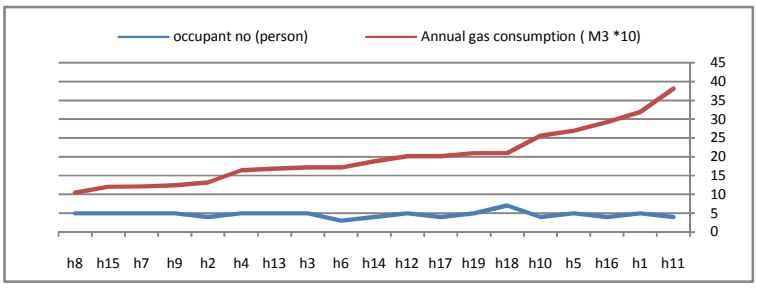

Fig. 4: comparison of samples Occ and ranked annual gas consumption

International Journal Of Architecture and Urban Development
Vol.1, No.3, Winter 2012

concerns fossil fuels, it has an equally important share in the CO2 release. Due to Shirazurban land, residential sector and population growths in last decades, the consumption of energy (electricity, gas, etc.) and air pollution increased. Therefore understanding the causes of the problem in residential sector was important. Built area (BA) and occupant number (Occ) as two fundamental affective parameters on energy consumption were analyzed through 19 houses in Shiraz. In this paper the impact of built area and Occ on winter gas consumption (heating) were evaluated.

The average operation months of gas heating consumption were from first of November up to end of April and the average maximum monthly gas consumption of sample houses was in February. The result showed although the case studies houses have different BA from 80 t0 200 m2andOcc from 3 to 7 persons, the biggest and busiest houses did not consume the maximum annual gas consumption and so the smallest and low occupant ones about minimum consumption. Therefore, the samples heating consumption was not so related to the BA and Occ. some of the reasons were the consumption culture, inhabitant behavior and low gas prices in Iran.

REFERENCES

1.Chen, Shuqin; Hiroshi Yoshino, Mark D. Levine; Zhenhai.Li, 2009,"**Contrastive analyses on annual energy consumption characteristics and the influence mechanism between new and old residential buildings in Shanghai**", China, by the statistical methods, Energy and Buildings, Volume 41, Issue 12, December, PP 1347-1359.

2.Hens H; G Verbeeck; B Verdonck; 2001,"**Impact of energy efficiency measures on the CO_2 emissions in the residential sector**", a large scale analysis, Energy and Buildings, Volume 33, Issue 3, February, PP 275-281

3.Karimi, A., B.Karimi, B., A.Roshani, A., (2009),"**Evaluation of Shiraz physical development with emphasis on natural factors**", Journal of the geographical Zagros landscape, volume 1, issue 1, 5-18.

4.Lenzen Manfred, Christopher Deya, Barney Foranb, 2004,"**Energy requirements of Sydney households**", Ecological Economics,Volume 49, Issue 3, 1 July, Pages 375-399.

5.Lucas Blasco, E Hidalgo, W Gomez, R Rosés (2001),"**Behavioral factors study of residential users which influence the energy consumption**", Renewable Energy Volume 24 Issues 3-4 Pages 521-527.

6.Results of General Population and Housing Census 2006 and 1996, Iran statistical center, Shiraz, Iran

7.Toloeyan, A., 2006,"**Energy management and its relationship to sustainable development and environmental pollution**", Fifth Conference on Optimization Buildings Fuel Consumption, Tehran, Iran

8.Yeo Myoung-Souk, In-Ho Yang, Kwang-Woo Kim,2003,"**Historical changes and recent energy saving potential of residential heating in Korea**", Energy and Buildings,Volume 35, Issue 7, August 2003, PP 715-727.

9.Yigzaw G. Yohanis, Jayanta D. Mondol, Alan Wright, Brian Norton, 2008,"**Real-life energy use in the UK: How occupancy and dwelling characteristics affect domestic electricity use**",Energy and Buildings,Volume 40, Issue 6, PP 1053-1059.