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AN ANALYSIS OF URBAN FEATURES ON ENERGY CONSUMPTION AT NEIGHBORHOOD SCALE

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Abstract
There has been a growing interest in discovering the human effects on environment and energy consumption in recent decades. It is estimated that the energy required for transportation and housing are respectively, 20percent and 30percent of total energy consumption. Furthermore, the residential greenhouse emissions depend on urban forms and structures. This paper explores the effects of urban features on residential energy consumption. Different urban features were compared and discussed, including the urban density, typology, housing location, building area and construction materials. Two residential districts in Shiraz, south of Iran, were selected as case study areas. In order to achieve this goal, statistical analysis is utilized. Correlation analyses in linear regression were conducted to investigate the strength of each factor on energy consumption. It was found that certain urban form variables were meaningful in explaining the significant variances in energy use. The result shows how much impact each urban feature has on residential energy consumption. Density and climate changes have the most significant impacts on the energy consumption.

Keywords: urban planning; physical features; energy consumption; Shiraz

1. Introduction

The world energy crisis and magnificent growth in energy consumption have made the energy optimization as mandatory task around the world. On contrast, the quality of urban life is dependent on energy sources and supplies. Some evidences show that energy consumptions of Iranian big cities are significantly higher than that of international norms. In fact Iran has plentiful energy resources and it has been one of the major exporters of oil in Middle East since 1910s. Also it owns about 15 percent of world gas sources. Despite of these facts, Iran has to spend four million dollars to import fuel. Iranian total energy consumption is estimated to be equal 3.5 times of Turkey, 0.75 times of China, 14.5 times of Japan and 5 times of the global average (Iran's Energy Data, EIA, 2006).

The term of energy is used to describe "the state of a particle, object or system that is attributed as the power to define the ability to work" (Ness, 1998). Energy can be classified into different categories based on its release and affecting other factors. Therefore it has various forms such as heat energy, electrical, chemical, nuclear and radiation.

In this study, two types of electrical energy and chemical energy has been studied: household electricity consumption, transportation and domestic consumption of gas as chemical energy. It is estimated about 30 percent energy consumption goes for transport sector and 20 percent are spent in daily household activity.

While warning of ending global energy resources is dates back to late 1920s, however, conservation strategies have been appeared since 1973 after soaring oil prices energy. The bulk of research on this area has increased significantly from the 1980s. With main focus on the impacts of urban development on energy some of them are at the household level (e.g. IPART, 2004a; Lenzen, 2004), although at this level research is still limited. This is mainly due to the lack of relevant data relevant for different locations, densities and housing types (Bunker & Holloway, 2003). Moriarty (2002) analyzed energy usage in the inner and outer suburbs of five Australian capital cities. According to this study inner city residents used less energy and water per capita than their outer suburban counterparts when controlled for income level. This study recommended that a change towards non-motorized modes and public transport has an important potential in reducing energy usage.

Webster and Tomalty (2009) attempted to find the potential link between urban form, socio-demographics and energy use in residential neighborhood of metropolitan Toronto. So due to the different characteristics of houses and apartments, two different approaches were taken to model energy use. Finally in this study resulted in improved analytical capability including for example the ability to check representative house types to be simulated against the mix of housing types in the model. In the University of Cambridge, Ratti, Baker and Steemers (2004) explored the effects of urban texture on building energy consumption. Different methods were suggested and proposed and discussed, including the calculation of the urban surface-to-volume ratio and the identification of all building areas that are within 6 miles (9.7 kilometers) from a façade. The research proved that the surface-to-volume ratio, while being an interesting morphological index, does not explain the total energy consumption in urban areas. Better parameters seem to be the ratio of passive to non-passive zones.

2. Method of study

This study deals with investigation of the urban features (density, number of floor, materials etc.) influence on energy consumption at household level. It seeks urban, transportation and social conditions that contributes to different levels of energy consumption. The conceptual model of the study is depicted in Fig.1.

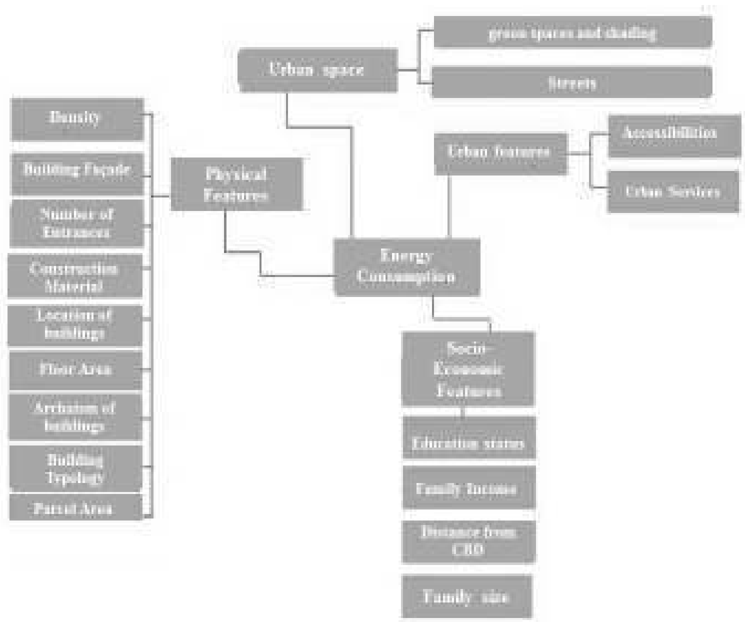

Fig.1. Conceptual Model of Study

2.1 Data

Physical characteristics of parcels were extracted from GIS data base. Some 140 questionnaires were completed by residents of case study areas asking them giving Information about the characteristics of social, economic status. The data of the gas consumption were obtained through reading gas bills of all household.

2.2 Study area

Shiraz is the sixth most populous city in Iran and is the capital of Fars Province. The two districts have been chosen basing on their different location, development history and urban density. *Eram* is located in the geographical center of the city and *Maaliabad* is in the northwest. The network distance of these two districts to the Imam *EmamHossein* Square (in downtown) are 2.6 kilometers and 13.7 kilometers respectively. The areas of *Eram* and *Maaliabad* are 35.5and 30.1 hectares respectively (fig.2).

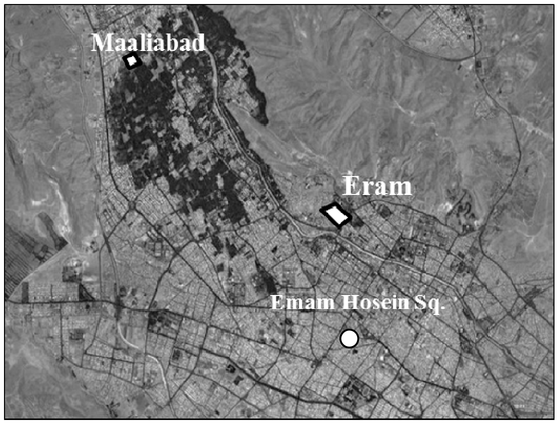

Fig.2.The location of Two case studies

The average family size of *Maaliabad* with 3.8 members was higher than *Eram* with 3.5 members. The monthly income level of *Eram* was 1.2 times higher that of *Maaliabad*, as can be seen in the table 1. The average travel time of the people in *Maaliabad* with 46.3 minutes was longer than that of *Eram* with 29.7 minutes.

Table1. Socio-economic features of two districts (R:Iranian Rial)

districts	Family Size		sex	Age average	Average family income		Average cost of oil for transportation	
Eram	Max:5	3.5 member	Female 16 percent	67.4 years old	Max 60 million R	24.7 million R	Max 5 million R	19.569 thousand R
	Min:2		Female 84 percent		Min 9 million R		Min 350000 R	
Maaliabad	Max:10	3.8 member	Female 8 percent	46.7 years old	Max 30 million R	19.96 million R	Max 2 million R	9.693 thousand R
	Min:2		Female 92 percent		Min 6 million R		Min 200000 R	

The share of work trips made by car in *Eram* and *Maaliabad* are respectively 74 percent and 70 percent. Despite farther from CBD, *Maaliabad* has higher figure in in public transport usage than *Eram* due to travel cost saving. In terms of modal choice for educational trips, the share of taxi use of *Eram* was 12 percent higher than that of *Maaliabad*. There was a moderate difference between school students travel and university students pattern. (fig.3). The reasons can be proposed as being close to downtown and having better access to public transport for students.

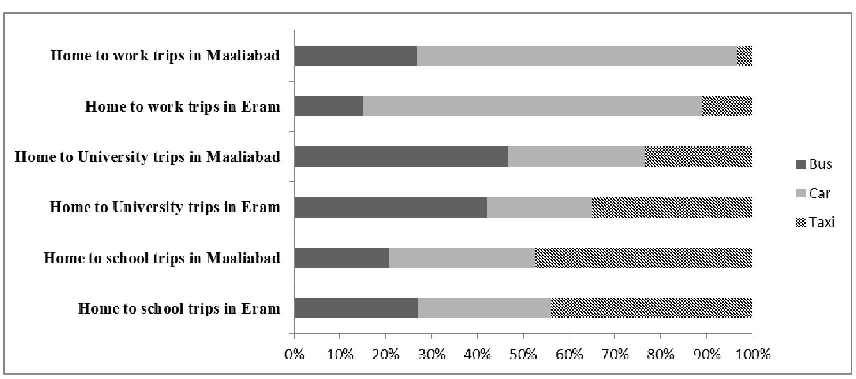

Fig.3 Travel Modes in Eram and Maaliabad

Eram buildings are older than *Maaliabad* ones thus making the quality of differences. While *Maaliabad* includes, 24 percent of new built homes, this figure for the *Eram* is only 8 percent. The numbers of entrances for the buildings in two areas are similar. On the other hand, the average floor area ratio (FAR) for two areas is 60 and 300 percent respectively. The details can be found in appendix1.

4. Results

Linear regression analyses were conducted to discover the effects of factors influencing energy consumption. The results are detailed in table2.

Table2. The regression results for Eram

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
	(Constant)	-94.295	13.081		-7.208	.000
	Number of Floor	22.141	1.822	.569	12.154	.000
	Setback	.646	.081	.372	7.944	.000

Dependent Variable: Energy Consumption

The following equation describes relationship between the explanatory variables and the dependent variable in *Eram*:

Energy consumption = -94.295+22.141(Number of floor) +0.646(Setback) ----------------------- (Eq. 1)

According to these results, number of floors and building setback are two main variables influencing energy consumption. Similarly, linear regression performed on the *Maaliabad* data. The results can be found in table 3. Building setback is inversely related to the energy consumption. The parcel with longer setback will attract more sun exposure so the energy consumption is expected to be lower.

Table 3. The regression results for Maaliabad

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
	(Constant)	-52.020	6.948		-7.487	.000
	Number of Floor	17.874	1.280	.499	13.966	.000
	Setback	-.331	.087	.358	3.791	.000
	Parcel Area	.002	.004	.057	.605	.057

Dependent Variable: Consumption

The following equation describes relationship between the explanatory variables and the dependent variable in *Maaliabad*:

Energy consumption = -52.0.20 + 17.874 (Number of Floor) - 0.331(Setback) + 0.002(Parcel Area) (Eq. 2)

The most important factors explaining the variances in energy consumption change are: number of floor, setback and parcel area.

5. Conclusion

The study gave an attempt to highlight our knowledge of urban energy consumption at neighborhood scale. Urban features in two sampled areas with different density and distance from city center have been studied.

According to the regression results, the impact of the most effective factors on energy consumption is as follows: Flour count > Setback > parcel Area. There is no association between energy consumption and several other aspects of urban form including building archaism, building façade and construction materials.

This study can be extended by choosing more number of urban districts locating in other geographical areas. Using more advanced statistical methods could help to improve the quality of findings. The results can be used by governmental agencies to amend land use policies and subdivision rules in hope of saving energy and achieving a sustainable community.

Acknowledgement

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Appendix1

Fig.5.Physical Features of Maaliabad and Eram

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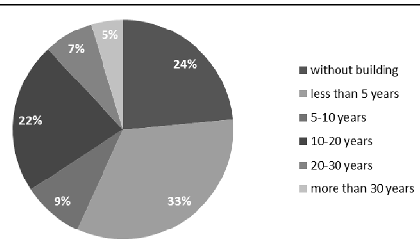
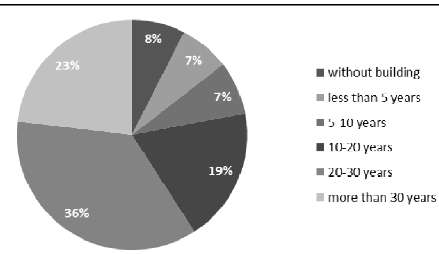
<tr><th>Maaliabad</th><th>Eram</th><th>Title</th></tr>
<tr><td>
</td><td>
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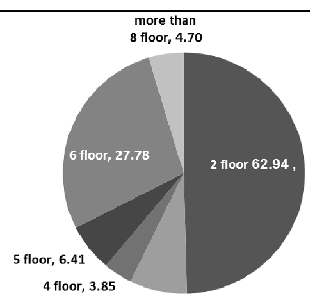
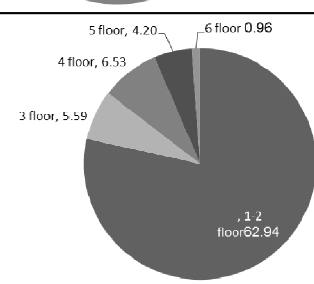
<tr><td>
</td><td>
</td><td>Main Entrance numbers</td></tr>
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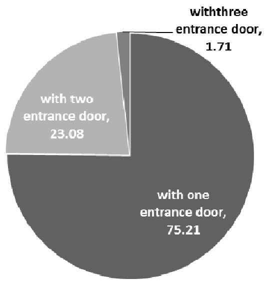
<td>
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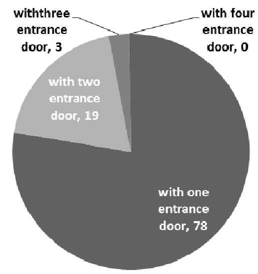
<td>
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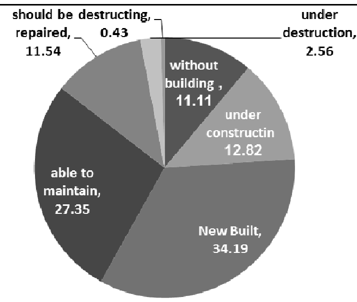
<td>
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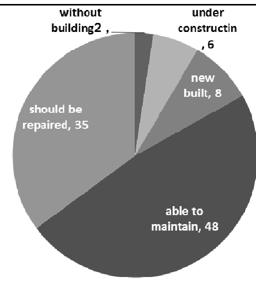
<td>
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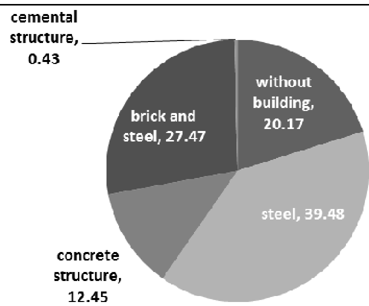
<td>
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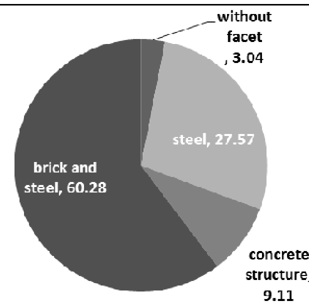
<td>
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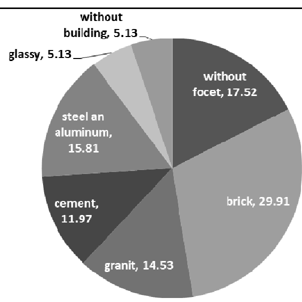
<td>
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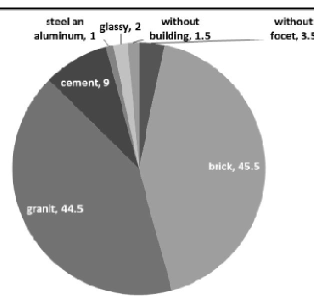
<td>
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