Energy Education Science and Technology Part A: Energy Science and Research
2013 Volume (issues) **31(3):** 1745-1756

Traditional rural house an example of energy efficient building in Fars province of Iran

Khosro Movahed[1,*], Kaveh Fattahi[2]

[1]*Azad Islamic University, Dep. of Architecture, Shiraz Branch, Shiraz, Iran*
[2]*Shiraz University, Faculty of Art and Architecture, Shiraz, Iran*

Received: 24 April 2013; accepted: 29 July 2013

Abstract

Today, most houses are dependent on new technologies with using of different kinds of energy such as electricity and fossil fuels. Looking for traditional techniques with energy efficient is very important in sustainable architecture. Learning some lessons of rural traditional architecture in Iran can help us to find ways to reduce energy consumption. These lessons can be useful for decision makers in energy strategies. This study is based on a research program, which has been carried out on rural house architecture in Fars province. Rural areas are the residential and productive places that have organic relationships with climatical, economical, social and cultural patterns. There are 1.63 million people living in about 350 thousand houses in rural areas in Fars province in Iran that are different in terms of size, technique, type and age of construction. The majority of the rural traditional houses have been constructed to reduce the energy consumption. In this paper we try to introduce a traditional way of rural house architecture in Iran. The main objectives are, to show that, rural houses are efficient buildings and also, how reduction in energy consumption has been achieved in traditional rural houses. To reach such an objective, this paper will address: (1) The current condition of rural house architecture in Fars province; (2) Some key analysis of form, structure and spatial patterns of rural house architecture in different parts of Fars province;(3) Comparative analysis of house architecture in different climatic zones of Fars province; (4) Several guidelines for rural house constructions; and (5) Essential readings for rural planners, architects and local and national government officers.

Keywords: Fars province; Climate; Traditional rural house; Energy efficient

1. Introduction

When choosing a place to live, people need to choose a certain kind of dwelling in a certain kind of residential area. This decision is influenced by a number of different factors such as ecology, economy, policy and society. These issues have been studied extensively in different disciplines engaged in housing research [1].

*Corresponding author. Tel: 009-871-1649-0723; fax: 009-871-1641-2487.
E-mail address: khmovahed1@yahoo.com (K. Movahed).

Rural areas are the residential places that have a more direct and organic relationships with natural, ecological, economical, social and cultural patterns. Considering this, makes traditional rural houses as a very good example of studying these factors and to check how house design has synchronized itself with the impacts of different design issues. Therefore, many researchers have tried to recognize and introduce these factors in rural house architecture. Also in Iran as a country with more than 20 millions of rural inhabitants, several researchers have tried to recognize these factors. In a recent research Movahed and Fattahi [2] listed all the key factors that are engaged in designing traditional rural houses in Iran in a simple diagram (Fig. 1). Studying these factors reveals how Iranian rural house builders have used different creative techniques to develop their houses in various villages of Iran over millennia.

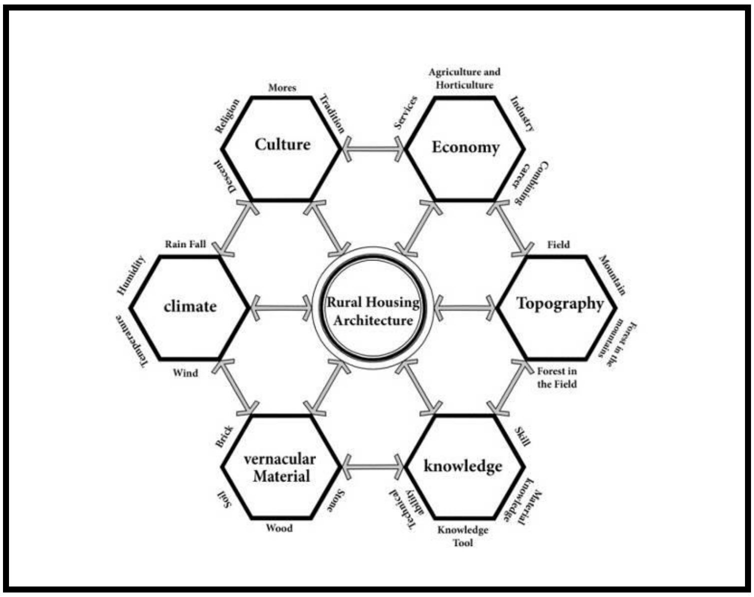


Fig. 1. Simple diagram of key factors of traditional rural houses in Iran.

Generally speaking, the rural house architecture in Iran is considered as architecture without architect. Given this and also that the layout drawn up by the residents had a more sensitive internal pattern and were more appropriate in responding to external factors such as *climate* or *culture* [3], we believe learning from traditional rural houses can help us, directly from past without extra expenditure, to take lessons in how to deal with different design issues.

Among different key factors that have been introduced by Movahed and Fattahi [2], they have highlighted the consideration of local *climate* and *topographic* conditions as two of the most influential factors affecting sustainable design of buildings and building services systems of Iranian rural houses. They suggested without good information and understanding of the local climate, it is not possible to study and achieve optimal building design and efficient building services operation. The impacts of climate and topographic considerations are more vivid in rural house architecture due to the shortages of electricity and fossil fuels in rural areas in the past. The Iranian rural house builders had been responsible for finding and manipulating different techniques to make energy efficient buildings in different villages.

In a global view, several scholars have focused on the importance of climate in formation of rural architecture. It has been believed that architects not only should but also have to consider the climatic conditions for their favor and benefit from them, such as sun, wind, and water. Hui [4] concluded that climate has a major effect on the performance of the building and its energy consumption. One of the ideas in his article is to investigate the impact of climate on rural house construction. It involves the exploration of how house constructor is sensitive to the climatic conditions of its village. Therefore, rural buildings can be considered as “climate modifiers” which could take advantage of local weather to enhance their architectural integrity and environmental quality [5]. The basic thinking lies upon the evaluation of climatic influence and the optimization of building environmental performance. In other words, we are trying to minimize the resource consumption and environmental impact through cooperation with external climate [6].

In the past human history, climate considerations are very important in building urban and rural houses [7]. Accordingly, Golsmith [8] suggests that climate has affected indigenous building construction since the beginning of time as cultures have traditionally been very sensitive to the temperature and moisture surrounding them. However the first documentation of architectural design with climate interests in mind dates back to fourth century B.C. in Greece. The philosopher Vitruvius is quoted as saying: “We must at the outset take note of the countries and climates in which buildings are built” [9].

In Iran also Behbood [10] considers that climate have played a major role in the traditional building architecture and its energy consumption in hot dry area of Iran. While several researches have focused on the effects of local climate and topographic consideration on urban house architecture in different parts of Iran ([11]; [12] and [13]) there are a few researches that have studied these factors in different Iranian rural house designs. This is while; Iranian rural inhabitants have inherently developed a unique and indigenous architecture in response to different climates, just as he wears different clothing such as furs in winter and light cottons in summer. These organic solutions contain many insightful approaches to efficient energy use in building types. Therefore, this paper attempts to check the impacts of these factors on formation of rural houses within a sampled area in Iran.

To do so Fars as one of the provinces in Iran with a vast variety of climate and topographic conditions within its borders and hence inclusion of a large variety of rural architecture in its different villages, have been selected. This is a characteristic that made Fars province as the ideal case study to be focused while researching on rural house architecture in Iran.

Fars Province is one of the 31 provinces of Iran and known as the *Cultural Capital* of the country that is located in the south of Iran (See upper-right side of Fig. 2). It has an area of 122,400 km² and as of 2011 it had a population of about 4.57 million people of which 64.3% were registered as urban dwellers, 35% villagers, and 0.7% nomad tribes**.** There are 1.63 million people living in about 350 thousand houses in 4300 villages [14]. Therefore, in this paper several different villages within Fars province have been selected as target population. Accordingly, this paper tries to answer the following issues as its main research questions:

- What are the main characteristics of traditional rural houses in Fars province?
- How rural house builders in Fars province have synchronized their designs with the impacts of climate and topography to enhance their building’s energy efficiency?
- Can we distinguish any rural design patterns that have been used in the past and have the potentiality to be adopted in the current rural houses to enhance their energy efficiency?

To address these main issues, current paper is organized as follows: after this introductory part, methodology is introduced in Section II, being followed by the explanation of the investigated province in section III. Results which show characteristics of rural traditional houses in Fars province and also introduction of several energy-efficient rural design patterns will be presented in section IV. Finally by concluding our results, several recommendations will be suggested in section V.

1. Methodology

To reach our goals and as our research method, firstly, we have listed all the villages in Fars with more than 90 families which have been constructed at least fifty years ago, as our target population. There are 897 villages in Fars with such characteristics.

Then, different climatic data were gathered from all 24 main weather stations within Fars province. Fig. 3 shows the map of Fars province and location of these 24 weather stations spreading all around the province.

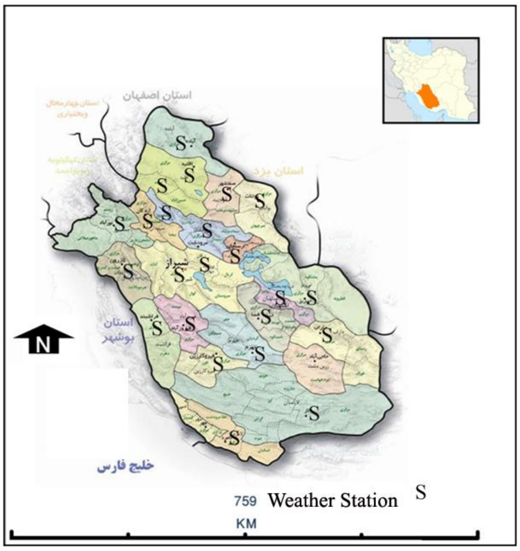


Fig. 2. Map of Fars province and the location of weather stations.

The definition of climate in this paper is the ten years weather patterns of a specific village. The average minimum and maximum temperature, the average maximum and minimum humidity and also the average precipitation are taken into effect in determining the village's climate. Due to the shortages of climate data in some of weather stations, only last ten year's climate data was used. Table 2 shows the average 10 years' climate statistics of all weather stations within Fars province from 21st of March 2001 to 20st of March 2011. A simple glance towards the gathered data reveals that we are dealing with a province in which 32°C temperature degree difference within a same day in its two different villages can be recorded. Therefore, we are facing a province with a vast variety of weather conditions within its different regions (as an example, compare Mean Minimum Temperature of Eghlid and Ghirkarzin in Table 1).

In the next step with the SPSS software and based on the climate data that were gathered and with the *q-mode cluster analysis*, Fars province has been divided into five main *climatic zones*. Fig. 3 and Table 2 show the results of this q-mode cluster analysis by SPSS software. In the *q-mode cluster analysis* method some clusters are being recognized based on the similarities of the data that were inputted. In this paper clusters are groups of villages that have more than 60% of similarities in their last 10 years climate data. These groups in this paper are called as *climatic zones*. Therefore, by climatic zone we mean different villages within a specific region in Fars province that have experienced a similar climate conditions during last 10 years. Using this method, five main climatic zones in Fars province have been recognized (Table 2).

Table 1. Average 10 years' climate statistics of weather stations in Fars (21st of March 2001 to 20st of March 2011)

Weather Stations	Mean Maximum Humidity(%)	Mean Minimum Humidity(%)	Mean Maximum Temperature(°C)	Mean Minimum Temperature(°C)	Mean Precipitation (mm)
Abadeh	55.35	18.72	22.93	7.32	137.81
Arsenjan	46.05	20.77	25.32	11.5	195.46
Estahban	56.45	20.34	25.49	9.34	280.58
Eghlid	50.18	17.69	19.74	6.28	352.37
Izadkhast	48.29	21.78	20.69	6.81	180.21
Takhte Jamshid	67.47	27.55	25.64	9.03	308.49
Bavanat	44.55	16.75	21.15	6.66	156
Jahrom	67.7	22.75	29.84	11.9	279.03
Darab	58.28	20.96	29.93	14.35	238.88
Zarghan	62.65	22.9	25.58	8.17	284.66
Zarrin Dasht	47.53	15.63	31.17	15.13	208.3
Sepidan	51.15	28.37	20	9.85	647.54
Dorudzan	62.66	22.04	24.54	10.93	461.14
Shiraz	62.68	20.59	26.52	10.56	287.73
Safa Shahr	56.09	20.9	20.45	3.2	164.86
Farashband	67.3	21.7	30.9	12.6	238.4
Fasa	62.15	21.52	28.18	10.5	275.63
Firuzabad	48.45	23.3	27.15	14.4	358.3
Ghir Karzin	50.2	23.2	32.6	18.9	337.2
Larestan	58.58	22.16	32.02	15.72	156.17
Lamerd	59.68	22.71	34.12	16.99	185.52
Mamasani	62.2	21.2	29.53	13.03	412.67
Neyriz	47.3	22.37	25.81	12.97	200.12
Kazerun	61.96	23.3	30.12	15.56	295

Source: Fars Province Weather Station Centers

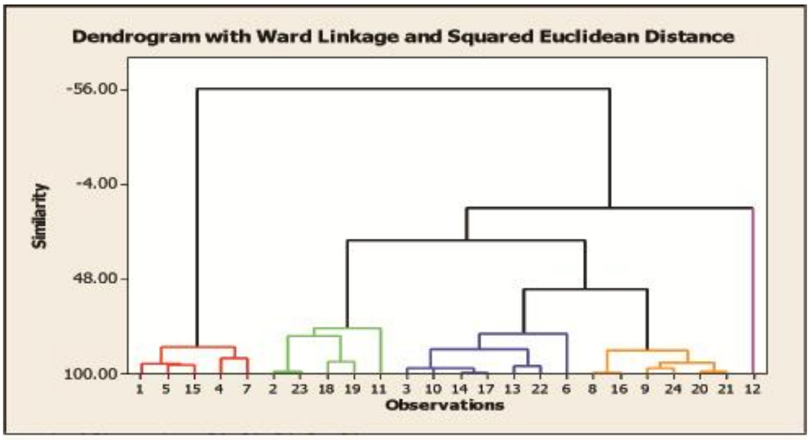


Fig. 3. The results of q-mode cluster analysis by SPSS software.

Table 2. List of weather stations in each climatic zones of Fars province

Climatic Zones	Weather Stations
Climatic Zone 1	Abadeh, Eghlid, Izadkhast, Bavanat, Safa shahr
Climatic Zone 2	Arsenjan, Firuz abad, Ghir Karzin, Neyriz, Zarrin dasht
Climatic Zone 3	Estahban, Takht Jamshid, Zarghan, Dorudzan, Fasa, Shiraz, Nurabad
Climatic Zone 4	Jahrom, Darab, Farashband, Larestan, Lamerd, Kazerun
Climatic Zone 5	Sepidan

Source: Authors

Finally, considering those five climatic zones as our *clusters* with the *cluster sampling method*, 60 villages from the initial list of 897 villages have been selected. Then, the villages of each zone have been divided due to their topographical conditions. Table four shows the sampled villages in each climatic zone and their topographic conditions.

Accordingly we have analyzed the house architecture in these villages through different methods such as direct observation, filling questioners, interviews and the exact mapping of sample houses from each sample village. As a result we try to find the impacts of climate on rural house architecture and to find how the rural houses are energy efficient in Fars province.

The topographical conditions mean the villages that are located in forested area, mountainous area and Plain area. The comparison of houses will be made of the different topography and climate condition in different villages. The houses surveyed in this paper were typical examples of houses through the each sampled villages. Houses will be evaluated in terms of construction criteria; such as, buildings forms, materials, technique, direction to the sun and the constructed lots, according to the climatic characteristics of each climatic zones and its topography. For this purpose table one was filled for each sampled villages.

Table 3. Influential factors of rural housing architecture in sample villages

	A) Environmental Factors							
1	Building Orientation	towards Wind	towards Sun					
2	Materials Application	Footing	Columns	Windows	Doors	Floors	Ceilings	Walls
3	Architectural Elements Provision	Trees	Sloped-ceiling	Domed-ceiling	Ivan Ceiling	Shade/Brise soleil	Wind-catcher	Water pool
4	Architectural Spaces Inclusion	Terrace	Balcony	Ivan	Central Courtyard	Cistern	Garden	Cellar
5	Building Density	Extended	Compact					
6	Building Ground Level	Internal Parts' Level	Ivan Level					
7	Seasonal Movements	Winter-part inclusion	Summer-part inclusion					
	B) Technical Factors							
1	Design Issues	Plot Size	Later Extension	Design Documents	Two Storey Building	Roof Staircase	Roof Accessibility	External/Internal Staircase
2	Constructional Issues	Ext. Wall Lining	Int. Wall Lining	Bath Mortar	Parapet (Balcony)	Parapet (Roof)	Quake-Resistant Details	Window Lintel
3	Application of Local Materials	Others	Wall Finishings	Windows	Doors	Floors	Ceilings	Walls
4	Application of Design Modules	in ELEVATIONS	in PLAN					

Source: Authors

Table 4. List of sampled Villages in each climatic zone and their topographic conditions

Climatic Zones	Forested Area	Mountainous Area	Plain Area
Climatic Zone 1		Sangbor	Amirabad, Ghazian Sofla, Asepas
Climatic Zone 2	Burkan	Mozafari, Abgol	Miandeh, Khosuyeh, Bohuyeh, Bavarian, Shurab, Shahrake Ghalat, Aliabade Malek, Kamal abad
Climatic Zone 3	Mehranjan, Maharloo, Ghalat	Jargheh, Juyjan, Shul, Darakuyeh, Dashtak Marageloo,SahlAbad, , Dashte Arjan	Kamjan, Bande Amir, Jelyan, Tarbore Jaafari, Harom, Mah Farokhan, Kamal Abad, Darbe Ghaleh, Baba Monir, Zafarabad
Climatic Zone 4	Mansuriyeh, Neamat Abad, Chekak, Bahrestan	Kurdeh,Davan,Kalani Ghaleyni,LayeZangan Abduyi,Kareh Muchi, Laghar	Duban, Gheyb Elahi, Mazayejan, Fishvar, Sharghi, Kahnuyeh, Karadeh
Climatic Zone 5		Dalin	Dame Ghanat, Kushk Hezar, Rudbal, Jyan(Shahid Abad)

Source: Authors

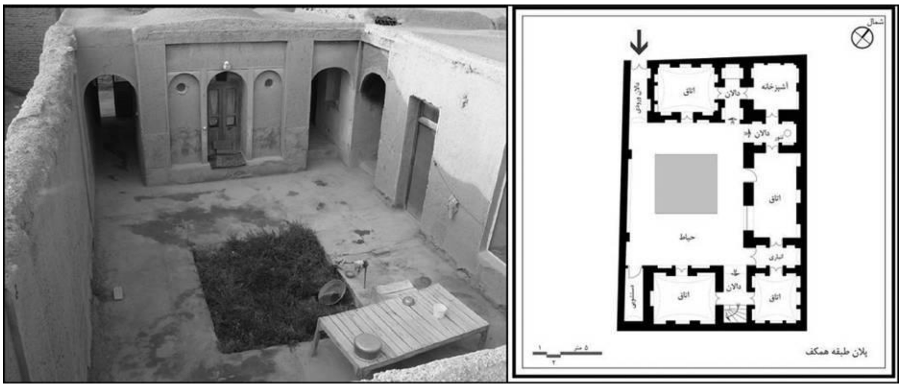
4. Results

This paper provides examples of climate-responsive housing construction in rural areas in Fars providence of Iran. In this section, characteristics of rural traditional houses in different climate zones and the reasons to show why rural traditional houses are energy efficient will be present.

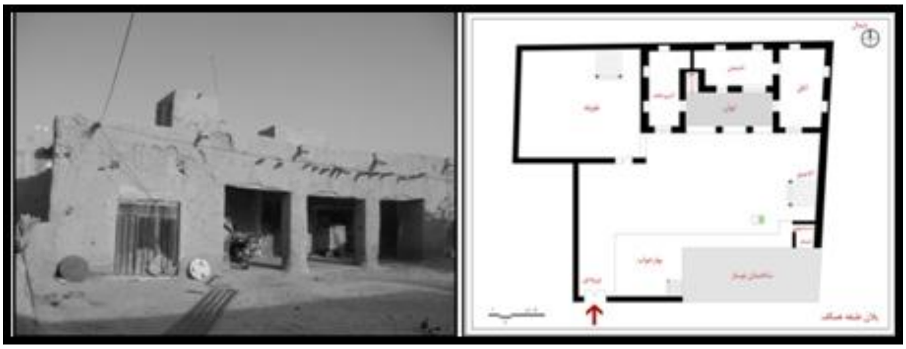
4. 1. Characteristics of rural traditional houses in different climate zones

Rural traditional houses are deeply in harmony with nature, and make life more enjoyable simply by harnessing the natural elements themselves. Most building material in Fars province, especially in plain areas are composed of mud and its derivatives. In fact, nothing but mud and mortar could be used in these villages because there are no other building materials in the region.

Housing construction is used as building material in the form of mud. In such regions, one cannot find any other building material except unbaked bricks and mud which strongly resist the incessant sun rays in the very warm months of July and August. Use of local construction materials such as stone, wood, mud or mud brick are the most common material used to make rural traditional houses in Fars province. The mud mixtures often included earth, soil, dry vegetation, and stone aggregate. The surface of the mud structure is decoratively finished in either, glazed tiles, rendered adobe mud, stucco, or plaster. Fig. 3 shows five kinds of the rural houses in different parts of Fars province.

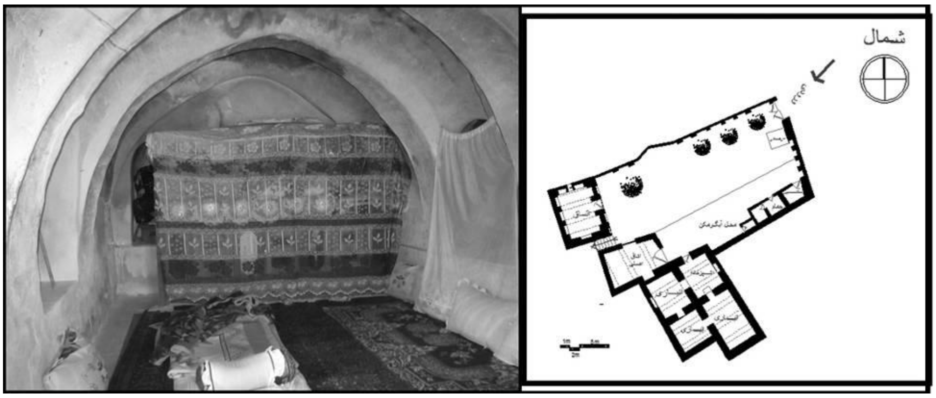


Zone 1 (AmirAbad)



Zone 2(Khosuyeh)

Zone 3 (Dashtak)



Zone 4(Chekak)

Zone5 (Dalin)

Fig. 1. Five kinds of the rural houses in different parts of Fars province.

The climatic zone one and two are similar in Preventing the raining water entering the houses' indoor. The villages are usually located on the southern slopes of rocky plateaus to protect them from west-northerly winds and to take advantage of sun exposure.

In zone three, summer daytime temperatures goes over 40oC, and with low humidity, drop to 10-15oC at night. Some villages have mild winters, while others may reach subfreezing temperatures in coldest months. The houses are built in different forms and the builders tried to reduce the initial embodied energy as well as cost.

Hence locally sourced materials using the minimum of power in production led villagers to build houses in very simple way. Houses are constructed with one or two floor depend on its climate condition. The height of building differs in different areas.

In zone four which the climate is hot and dry, the most preferred house plan is one with a Courtyard. In order to minimize the area affected by the solar radiation, compact forms are Chosen. By arranging those forms with courtyards, shady areas can be obtained. In courtyards, with the help of water and plants for evaporative cooling, the floor temperature can be minimized by the high walls surrounding the courtyard, shady areas can be obtained and the open areas can be used during the day. Courtyards have different forms depending on the topography of the site of the house.

Eyvan and Revak, semi-open areas, are used to create shady and cool living spaces during the day. The Eyvan, three side a closed passageway in front of the ‘‘rooms’’, permits a common life inside (an open living room inside the house). Usually they are oriented to the south. Especially, south and east oriented Eyvans are very cool and provide shady places during summer afternoons. The Revak semi-open colonnade arranged in the courtyard always provides shady areas.

In zone 5, which the weather is cold and too much rain and snow in winter, house builder objectives are maximizing solar gain and minimize wind exposure..

Most of rural houses usually constructed to withstand climatic extremes and to make indoor conditions comfortable regardless of weather conditions outside. In Fars Province which most parts have hot and dry climate, some precautions against the solar radiation are;

Minimization of the area and the number of windows;

Construction of windows at a high level to block floor radiation;

Minimization of the absorption of heat by facades by choosing white or light paint colors; providing natural ventilation especially at night;

Constructing a part of the house below grade, which is always cooler than the ambient outside temperature in summer.

Table 5. Energy-efficiency factors of rural housing architecture in five climate zones

Characteristic / Zones	Topographic Conditions	Seasonal Movements	Height from Ground Level	Plan Extension	Window Shader	Ivan Inclusion	South Direction	Courtyard Inclusion	Adobe wall Application	Stone wall Application	Two Floor Buildings
Climatic Zone 1	Plain	◑	◑	◕	◔	◕	◕	◕	●	◔	◔
	Mountainous	◔	◕	◔	◔	◕	◑	◑	◕	◕	◕
	Forested	—	—	—	—	—	—	—	—	—	—
Climatic Zone2	Plain	◑	◔	◕	◔	◕	◕	●	●	◔	◔
	Mountainous	◔	◕	◔	◔		◑	◕	◑	◕	◑
	Forested	◕	◑	◑	◔	◕	◑	●	◔	◕	◔
Climatic Zone3	Plain	◕	●	◔	◔	◑	●	●	●	◔	◑
	Mountainous	◑	●	◔	◔	●	●	◕	●	◔	◑
	Forested	◑	◕	◔	◑	◕	◕	●	◕	◕	◕
Climatic Zone 4	Plain	◔	◑	◕	◔	◕	●	●	●	◔	◔
	Mountainous	◔	◑	◕	◑	◕	◕	●	◑	◕	◑
	Forested	◔	◔	◔	◔	●	●	●	●	◔	◔
Climatic Zone 5	Plain	◔	◕	◔	◔	●	●	◕	●	◑	◑
	Mountainous	◔	●	◔	◔	◕	●	◑	◑	◑	◑
	Forested	—	—	—	—	—	—	—	—	—	—

No case Available	—			
Available Cases	0% to 25% ◔	25% to 50% ◑	50% to 75% ◕	75% to 100% ●

4. 2. Why traditional rural house is energy efficient building

Today, accessibility of different kind of energy and new technology have been said to be a partial cause for the changes in the rural house construction in Fars province. When observing rural traditional house examples in Fars province, it can be seen that most of the houses have been constructed by the materials with a high heat capacity as thick as possible. Most of the houses have north-south orientation and the outside areas provide relief from heat with thick, adobe walls. Thick adobe wall provides a high time lag for the transmission of the outside temperature to the internal area.

The most important factors affecting sustainable design of buildings and building services systems is the consideration of local climatic conditions and characteristics. Rural people especially in the south of Fars province, where the air is hot and humidity is low have used different techniques and materials for cooling their houses.

The electrical usage of houses in rural areas in Fars province is about 545 kilowatt/hours. Statistics of Fars province shows that its electricity consumption in 2008 was 215 billions kilowatt/hours. Study shows that 2 percent of Fars province consumption of electricity is used by rural inhabitants for evaporative coolers. It means about 4 billions kilowatt/hours was used by the evaporative coolers.

If only 1 percent of houses can be built by suitable traditional system, the thrifty of electricity will be 40 millions kilowatt/hours.

In order to increase the efficiency of country services (for example efficient electricity provisioning), the country itself must act correctly. Reducing the amount of electricity consumption in cooling or warming the houses, it needs keeps the houses cool in summer and warm in winter with lower electricity or utilizing techniques that use natural energy.
Study shows rural traditional house allow efficient cooling or warming, at a far lower electricity consumption.

Adobe walls have positive effect on keeping the house cool in summer and also increase heat efficiency in winter. Also, flat adobe roofs reduce the penetration of heat and use high-mass materials able to delay impact of hot mid-day sun by storing energy in mass of walls and releasing it at night through long-wave radiation emittance. The building is almost comfortable when the external temperature is high.

The external walls are with light colors that minimize the effect of solar heat. Houses have small windows and shuttered on the west. The vegetation in the courtyards temper the courtyard environment and the trees provide shade to the facades that reduce the amount of heat penetrating through walls. The building is almost comfortable when the external temperature is high.

5. Conclusion

Fars province's rural traditional house builders have used suitable techniques for different climatic areas. The houses have been improved over a long history of Construction. They have progressed to protect rural inhabitants from the unpleasant environments.

Houses have been constructed in proportion to the village's climatic conditions, which makes such ingenious use of local resources with applying very simple techniques. Many believe that, there is much to be learnt from rural traditional building techniques.

This study examined rural traditional house as an example for energy efficient building. The results show that if energy efficient be believed by people instead of constructing high energy buildings, it will reduce the amount of energy consumption in the country.

This paper concludes that according to some factors it is possible to address rural traditional houses, as energy efficient buildings. The main advantages of these buildings are as follow:

The simplicity of its construction, secondly, it is energy efficient, and finally, it is environmental friendly.

While each village in Fars is unique with its own geography, history, culture and climate, based on our analysis, this paper has identified some main principles of house architecture for different climatic zones of Fars province. Conclusively some important keys have been introduced that can form the rural house patterns in Fars province. Finally based on our findings from previous sections, we conclude some points for several parts of a rural house of Fars province in different climatic zones such as courtyard, entryway, rooms, Ivan, staircase, and roofs. We believe these points caused the traditional houses to be energy efficient and it can be applied in future rural house designs of each zone to decrease energy consumption.
This study also leads us to understand the traditional rural house architecture in Fars province and hence has introduced some main recommendations related to their new house buildings. Moreover, a range of practical strategies for house to minimize the heating/cooling energy demand for its inhabitants. It is clear that rural architecture is very complex but we believe this set of recommendations, along with the rural climate can be use in energy strategy too.
Some critical guidelines that have been introduced are as follows:

a- The old rural houses in Fars providence were designed for the climate that prevailed at the time of construction. Due to increasing expectations of quality of life and also climate change, the existing houses will not provide expected level of comfort in future. It is essential to adapt the houses for future conditions by considering traditional house construction techniques.

b- The information on the impact of climatic condition on houses construction will enable the architects to obtain advice and guidance for their new house design in rural areas in Fars providence

c- Local construction materials are linked closely to the provision of climate conditions, hence managing the use of materials in house construction is important in this issue;

d- Broaden public information and knowledge on the importance of rural climate have a key role in maintaining the rural sustainability of villages; and,

e- A comprehensive rural house construction law should be initialized to improve the quality of the rural house architecture.

References

[1] Mulder CH. Housing choice: Assumptions and approaches. Nether J Housing Built Environ 1996;11:209–232.

[2] Movahed K, Fattahi K. A study on the key factors affecting the rural house architecture in Fars province. J Housing Environment 2012;141:37-50.

[3] Memarian GH. Cultural Impact on Housing in Iran: A Comparison of Traditional Houses with contemporary houses. Second meeting of Construction and Architecture, Tehran, 1999.

[4] Hui SCM, Cheung KP. Climatic data for building energy design in Hong Kong and Mainland China, In Proc. of the CIBSE National Conference 1997, London, October 5-7; 1997.

[5] Torrance V B. Buildings as climate modifiers. Energy Buildings 1991;16: 907-913.

[6] Langston GA, Ding GKC. Sustainable Practices in the Built Environment, Butterworth-Heinemann, Oxford, 2001.

[7] Givoni B. Climate considerations in building and urban design. Van Nostrand Reinhold, New York, 1998.

[8] Salazar RS. Design with Climate: A Retreat for Vieques, Puerto Rico. University of Maryland, 2004.

[9] Derya O. Design with the climate in housing environments: an analysis in Northern Cyprus. Build Environ 2002;37:1003-1012.

[10] Al-Hemaidi WK. The metamorphosis of the urban fabric in an Arab-Muslim city: Riyadh, Saudi Arabia. J Housing Built Environ 2001;16:179–201.

[11] Vahid G. Climate study of Iran's historical architectures. Tehran University Press, Tehran, 2007.

[12] Mahmoud T. Urban structure and architecture in the hot arid zone of Iran. Payam publications, Tehran, 2002.

[13] Morteza K. Architecture and Climate. Khak press, Isfahan, 2004.

[14] Fars Housing Foundation. Statistical center Yearbook Report, Shiraz, 2008.