Architectural Dimensions and Beyond

www.adb.reapress.com

Arch. Dim. Bey. Vol. 2, No. 3 (2025) 195–203.

Paper Type: Original Article

Comparison of Energy Consumption in New and Old Buildings Case Study: Golali Abad Village, Tonekabon

Amir Hajjar[1,*], Ehsan Hajjar[1]

[1] Marlik Institute of Higher Education, Nowshahr, Iran; hajjar.amir@gmail.com; hajjar.ehsan@gmail.com.

Citation:

Received: 14 August 2024 *Revised: 18 October 2024* *Accepted: 21 December 2024*	Hajjar, A., & Hajjar, E. (2025). Comparison of energy consumption in new and old buildings case study, Golali Abad village, Tonekabon. *Architectural dimensions and beyond*, 2(3), 195-203.

Abstract

In recent decades, optimal energy consumption in buildings has become one of the main challenges in the field of sustainable development. Given the significant role of the building sector in energy resource consumption, a comparative evaluation of energy performance across different types of buildings is of particular importance. Therefore, greater attention must be paid to building design and the use of construction materials to minimize energy loss and maximize efficiency. The present study aims to compare energy consumption in two types of buildings—new and old—in the village of Golali Abad, located in Tonekabon County. The main research question is: What are the differences in the amount and pattern of energy consumption between old and new buildings in this village? This research adopts a quantitative, analytical, and field-based methodology, examining two sample buildings (One old and one new) in terms of fuel consumption, temperature fluctuations, the effect of internal heat-generating factors, wall thickness, and more—using Design Builder software. The study concludes that old buildings demonstrate lower energy consumption and higher efficiency compared to new buildings. The innovation of this research lies in its focus on a lesser-studied rural context and its integration of both quantitative and qualitative methods in analyzing energy consumption data, offering a localized model for optimizing energy use in similar regions.

Keywords: Optimal energy consumption, Indigenous pattern, Golali Abad village, Design builder.

1 | Introduction

In recent decades, population growth, the expansion of residential spaces, and the increased use of electrical appliances have led to a significant rise in energy consumption in the building sector. In Iran, buildings account for a large share of energy use, with the majority attributed to heating, cooling, and lighting. Meanwhile, the advent of modern construction technologies has changed building materials and design methods, which can significantly affect energy consumption.

Corresponding Author: hajjar.amir@gmail.com

https://doi.org/10.48314/adb.v2i3.38

In this context, comparing old and new buildings to identify factors influencing energy use and to propose optimization strategies is essential. Given the importance of energy optimization for sustainable development and reducing the costs borne by rural households, this research seeks to identify energy consumption patterns in rural buildings and provide solutions adapted to the region's climatic and economic conditions. The findings can benefit planners, architects, and rural development officials by contributing to improved living quality and energy conservation.

Despite numerous studies on energy consumption in urban buildings, there is a lack of comparative analysis focusing on rural areas, particularly in Mazandaran province. Moreover, most existing research has been theoretical or technical, with limited emphasis on field data and micro-level empirical analysis, such as that of a single village.

The questions addressed in this study include:

I. What differences exist in energy consumption between new and old buildings in the village of Golali Abad?

II. What architectural or technical factors contribute to higher energy consumption in older buildings?

The objective of this study is to analyze and compare energy consumption in old and new buildings in Golali Abad, Tonekabon, and to offer strategies for reducing energy use in older rural residential areas.

Preliminary investigations and field studies indicate that older buildings tend to have lower energy consumption and higher efficiency compared to newer ones. This research presents an innovative approach by focusing on a lesser-studied rural context and combining quantitative and qualitative methods in analyzing energy consumption data, thus offering a localized model for energy optimization in similar regions.

2 | Thematic Studies

2.1 | Climatic Conditions

The Caspian Sea coasts, characterized by a temperate climate and abundant rainfall, are considered one of Iran's mild regions. This area, enclosed between the Alborz Mountains and the Caspian Sea, consists of lowland plains where, as one moves eastward, both humidity and the overall temperateness of the climate gradually decrease [1].

Among the notable features of the region's vernacular architecture are the detached layout of buildings, which facilitates air circulation around them. Due to high humidity, buildings are commonly elevated on platforms or pilotis. Materials such as wood, adobe, and brick are typically used for walls, while wooden panels, clay tiles, sheet metal, and thatch are used for sloped roofs—materials compatible with the region's humid climate [2].

Climatic characteristics of this region include relatively high humidity throughout the year, heavy rainfall—especially in autumn—a small diurnal temperature range, and extensive vegetation cover [3]. A brief explanation of these features is provided below:

Humidity

Humidity is a defining feature of the northern Iranian climate and poses potential risks to both the health and comfort of residents and the durability of building materials. Moist walls exhibit reduced thermal resistance due to the presence of water, which lowers the interior surface temperature and increases the risk of surface condensation. Moist walls can lead to discomfort in indoor thermal conditions or higher fuel consumption for mechanical heating systems.

Humidity can also cause salt in the materials to dissolve and appear as efflorescence on wall surfaces [4]. It promotes mold growth, creates unpleasant odors, and damages building materials in various ways, such as dimensional changes and decay in wood, corrosion of metals, softening of gypsum and lime plasters, and delamination of joined wooden panels.

Wind and Ventilation in Buildings

Another important climatic factor in the region is wind, particularly its role in natural ventilation. Generally, effective natural ventilation in buildings depends on the pressure differences created by wind across the external facades. Temperature-driven air movement within buildings is usually negligible; thus, wind is the primary factor influencing ventilation and indoor air temperature, directly impacting occupants' comfort. The status of natural ventilation—or the air exchange rate—is a key determinant of human health and comfort. Natural ventilation affects humans in two ways: Directly, through the purity and speed of indoor airflow, and indirectly, by influencing temperature and humidity levels on interior surfaces. Natural ventilation serves three primary functions in buildings:

I. Supplying breathable air by replacing stale indoor air with fresh outdoor air.

II. Providing physical comfort by enhancing the body's ability to release excess heat via evaporation of sweat, thus relieving discomfort from perspiration.

III. Cooling the building's thermal mass when indoor temperatures exceed outdoor temperatures [5].

The importance of these functions, along with airspeed and exchange rate, depends on the local climate and season.

Regional Climatic Standards

Although the moderate climate allows for flexible building plans, elongating the building layout along the east–west axis is generally recommended. In terms of solar radiation intensity and its impact on building form, this region offers greater design freedom, since solar gain on walls—especially those facing east and west—is less intense than in other climates. Consequently, it is possible to employ free-form or even cruciform building layouts. However, stretching the form along the east–west axis remains essential [6].

3 | Research Background

In temperate and humid climates, architectural design aims to cope with heavy rainfall and high humidity, ensure effective ventilation, and prevent moisture penetration. Buildings are typically constructed on platforms or pilotis and oriented along the east–west axis [7]. They generally have open and expansive floor plans, feature wide verandas, and use sloped roofs with large overhangs. Large openings facilitate ventilation, and lightweight, moisture-resistant materials with low thermal capacity—such as wood and clay tiles—are commonly used to protect structures from humidity, as shown in the table below [3].

Table 1. Climatic characteristics of Northern Iran.

Climate Type	Type of Materials	Plan Type	Roof Type	Orientation	Building–Ground Relation	Window Area and Quantity	Use of Natural Ventilation	Building Layout	Exterior Color Type
Temperate and humid	Low thermal capacity	Expansive	Sloped	East to west	On wooden stilts or a masonry base	High	High	Dispersed	Light/flexible

Of course, traditional and vernacular architecture is no longer commonly seen in these regions today. Instead, buildings with steel or concrete structures, brick facades, and pitched roofs with so-called artistic forms—often blindly imitating western architecture—have replaced the earlier architectural characteristics. The interior spaces are now primarily designed merely to fulfill the basic shelter needs of families. These changes have led to the loss of a local architectural identity that was once adapted to the environment. One of the key consequences of this new architectural approach is the higher cost of construction and increased reliance on non-renewable (Fossil) energy sources for heating and cooling. New architectural approach is mainly due to the neglect of local materials and lack of consideration for the region's climatic features.

For example, in hot and dry climates, 70–80% of the total energy consumption during a building's lifespan is spent solely on ventilation, while only 20–30% is allocated to fulfilling other functional needs of the building [8].

In the older parts of the built environment, most buildings are quite old and primarily constructed using local materials such as adobe, mud, and wood. Most existing structures in this part of the village are single-story and interconnected. Typically, a residential unit in this village includes a living room, guest room, veranda, storage space, and a courtyard, with all these elements arranged around the courtyard. Structurally, there is no horizontal or vertical reinforcement in the walls or doors of these buildings, and no provisions were made to ensure the stability and strength of the buildings in the event of earthquakes or vibrations. Thus, the risk of natural disasters is significantly higher in these older village areas.

The two buildings analyzed in this study are located in the village of Golali Abad. This village has both old and new built environments and is administratively located in Khoramabad district, Tonekabon county, Mazandaran province. The village lies in a foothill zone, about 17 kilometers from the city of Tonekabon and 13 kilometers from Khoramabad.

3.1 | Comparison of Energy Consumption in Two Residential Units (Traditional and Modern)

The village consists of two areas: The old neighborhood (Sofla Mahalleh) and the new neighborhood (Olya Mahalleh). As shown in *Fig. 1*, the house located in the old neighborhood is nearly 80 years old and was primarily built using wood, adobe, straw-mud plaster, and a tin roof. Details of its wall and foundation construction are shown in *Fig. 3*. In this building, proper orientation, use of a veranda, and principles of vernacular architecture have been followed—and it remains inhabited to this day. These are features of climate-responsive architecture.

Climate-responsive design refers to an approach that minimizes or avoids the use of artificial energy sources by leveraging the natural energies present in the climate, such as wind. It also involves selecting appropriate building forms and envelopes. Like any successful design, this process should ultimately create a comfortable and pleasant living environment for the inhabitants [8].

Fig. 1. Golali Abad village, traditional house.

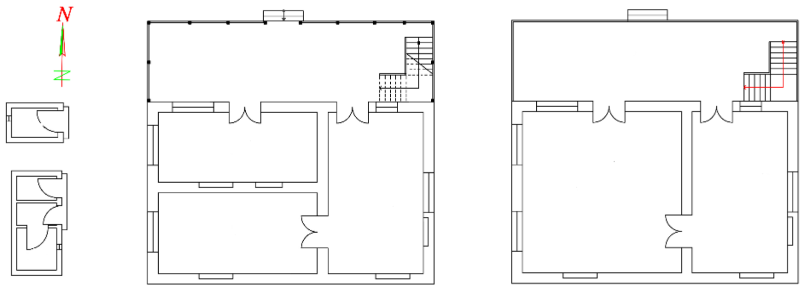

Fig. 2. Floor plan of the traditional house.

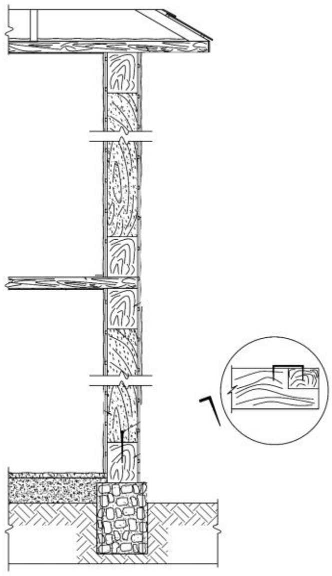

Fig. 3. Construction details of the traditional house.

The building shown in *Fig. 4*, located in the new part of the village, is constructed with modern materials such as cement, iron, plaster, and so on. Perhaps the only trace of the local vernacular architecture is visible in its sloped roof. Additionally, due to the thinner walls—which are characteristic of modern architecture and materials—the usable space in the new house is greater, and consequently, its weight is less than that of traditional houses. However, its walls do not provide good thermal insulation.

Fig. 4. Golali Abad village, new house.

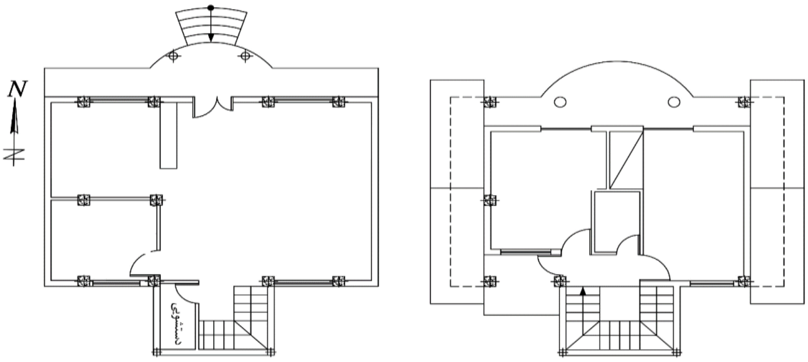

Fig. 5. Floor plan of the new house.

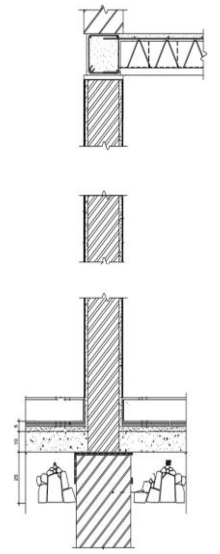

Fig. 6. Construction details of the new house.

4 | Analysis and Findings

For a precise analysis and comparison of energy consumption in the two types of buildings, the energy simulation software Design Builder was used [9], [10]. This software utilizes climatic data, building technical specifications, and consumption patterns to enable graphical evaluation of the building's thermal performance. The outputs serve as the basis for comparing the old and new houses in the study's case sample, which are examined in detail below.

The design builder output is in the form of charts that are analyzed based on the input data provided to the software [11]. It is worth noting that *Fig. 1* analyzes the old house and *Fig. 2* analyzes the new house. The horizontal axis represents the months of the year, while the vertical axis—divided into five rows from top to bottom—includes: fuel consumption, indoor and outdoor temperature fluctuations, heat infiltration from outside, the impact of internal factors such as lighting and occupancy on heat generation, heating load relative to the building area, and heat transfer.

The results derived from the software output and the comparison of these two charts are as follows:

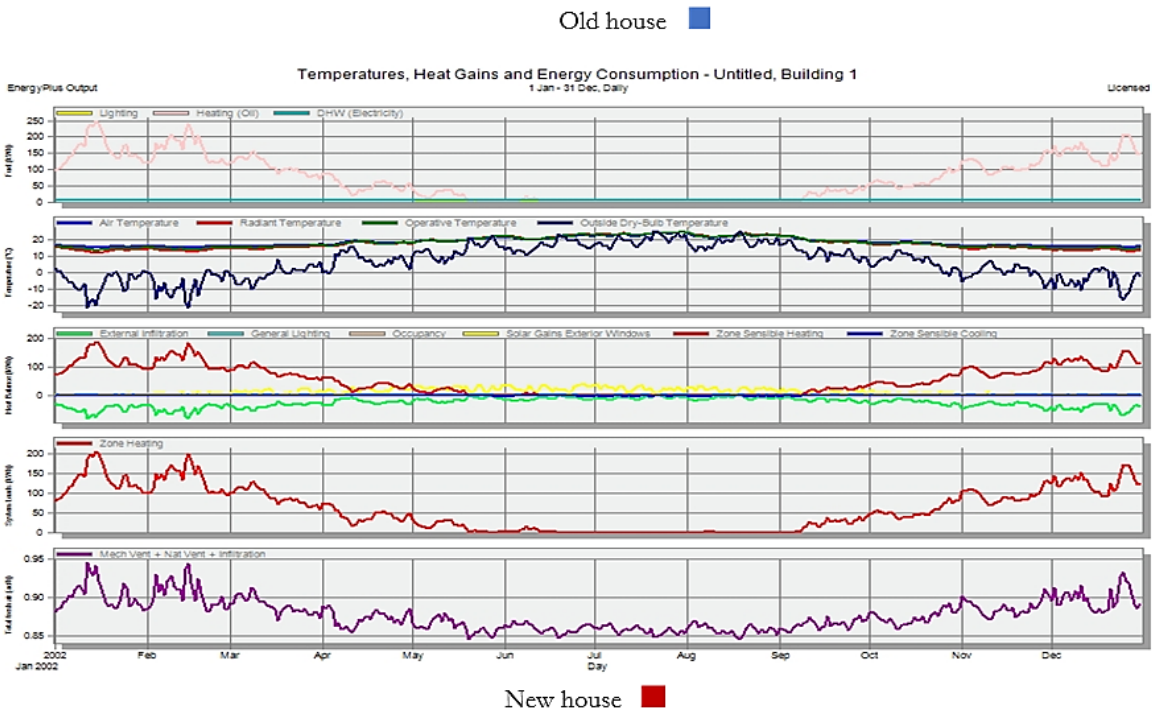

Fig. 7. Old house Vs new house.

Row 1

This row indicates the fuel consumption for heating the building, focusing on the colder months of the year. The type of fuel has been assumed to be natural gas for both buildings to enable a comparative analysis. According to the design builder software output, energy consumption in the traditional building is approximately 50% lower than in the modern building, despite having a larger floor area.

Row 2

In this chart row, the lower line shows fluctuations in the external environmental temperature, while the upper lines represent the indoor temperature variations. Although the traditional building consumes less energy, it experiences fewer indoor temperature fluctuations. The fluctuations are due to the use of materials with high thermal capacity and the thick walls of the old house.

Row 3

This section shows heat infiltration, including solar radiation, the presence of occupants, lighting, and other heat-generating devices (Assuming the number of occupants and light bulbs is the same for both buildings).

Row 4

This row illustrates the thermal load required for the building. Although the traditional building has a larger area, the thermal load of the new building is nearly twice that of the traditional one.

Row 5

According to the design builder software output, heat transfer fluctuations in the old building are high in winter due to single-glazed windows and wooden frames. However, the thick walls result in relatively low overall fluctuations. In the new building, the fluctuations during winter are much lower because of higher heating energy consumption compared to the old house.

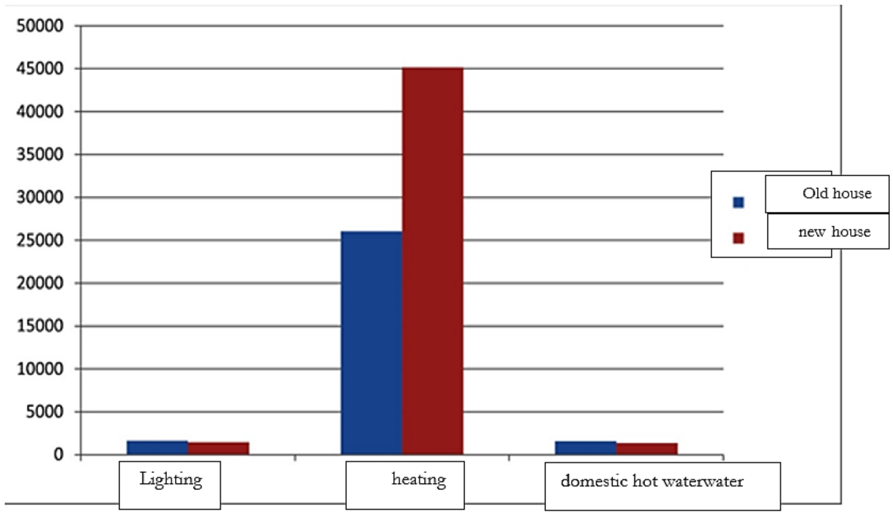

Fig. 8. Comparison of energy consumption.

5 | Recommendations

Based on the findings from the comparison of old and new buildings, the following strategies are recommended to reduce energy consumption and improve thermal performance in buildings located in temperate and humid climates:

I. Renovate old buildings using proper thermal insulation in walls and roofs.

II. Utilize optimized local materials such as treated wood or insulated bricks to maintain climate compatibility.

III. Increase openings and natural ventilation by designing verandas and opposite-facing windows.

IV. Install energy-efficient heating and lighting systems.

V. Educate residents on optimizing energy usage.

These measures will help reduce fuel consumption, enhance thermal comfort, and preserve vernacular architecture.

6 | Conclusion

The analysis of the Design Builder software outputs revealed significant differences in energy consumption patterns between traditional and modern buildings. The traditional house, which adheres to most climatic design standards, consumes significantly less energy compared to the modern building, which lacks proper orientation and uses materials incompatible with the local climate. The lack of appropriate orientation highlights the necessity of applying climate-responsive design principles and modern technologies in new constructions, as well as optimally renovating traditional structures. From the comparison of the traditional and contemporary buildings, we conclude that in the foothill regions of northern Iran's temperate and humid climate, an east–west orientation with openings on the north and south sides of residential buildings is ideal. This orientation enables cross-ventilation during warm seasons. According to the charts, the double-glazed windows of the modern building allow less cold air infiltration in winter compared to the single-glazed wooden windows of the traditional one. In terms of lighting and hot water, energy consumption between the two houses is relatively similar. However, when it comes to heating, the modern building uses excessively high amounts of energy annually, making it economically inefficient, while the traditional building consumes much less and uses more appropriate energy for heating.

Additionally, the wall thickness and materials used in the two buildings indicate that heat transfer is higher in the modern structure, which results in more temperature fluctuations and requires greater energy consumption to maintain thermal balance.

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Data Availability

The data that support the findings of this study are available from the corresponding author upon reasonable request.

Conflicts of Interest

The authors declare no conflicts of interest related to this work.

References

[1] Nejadsaravi, H., Arefeh, S., & Faghieh Khoshab, Z. (2023). The impact of materials and indigenous architectural patterns of temperate and humid climates on sustainability (Case study of indigenous architecture in Mazandaran province). *The third international congress of civil engineering, architecture, building materials and environment*. Civilica. (**In Persian**). https://civilica.com/doc/1969825/

[2] Tahbaz, M., & Jalilian, S. (2011). *Principles of climate-responsive architectural design in Iran*. Shahid Beheshti University Press. (**In Persian**) .https://press.sbu.ac.ir/book_81.html

[3] Ghobadian, V. (2011). *Climatic analysis of traditional buildings in Iran*. University of Tehran Press. (**In Persian**). https://B2n.ir/uw2752

[4] Heydari Esboui, E., & Farokhzad, M. (2023). Studying the impact of climate on indigenous housing design in temperate and humid caspian regions. *The third international conference on architecture, civil engineering, urban planning, environment and horizons of islamic art in the declaration of the second step of the revolution*. Civilica. (**In Persian**) .https://civilica.com/doc/1959615/

[5] Zarrin, L., Shemirani, S. M. M., & Tahbaz, M. (2022). Sustainable architectural patterns of native housing in hot, dry and cold climates with physical proportions criteria (Case study: Between BW and Ds climates). *Geography (Regional planning)*, *12*(2), 757-773. (**In Persian**). https://elmnet.ir/doc/2651905-41921

[6] Khosami, M. (2003). *limate and Architecture*. Nashr-e Khak Publishing, Tehran. https://www.scirp.org/reference/referencespapers?referenceid=2191426

[7] Ziabari, S. H. S., Zolfaqarzadeh, H., Jahan, F. A. M., & Salavatian, S. M. (2021). Quantitative analysis of orientation and proportion index of office building with the aim of maximizing the use of natural ventilation to reduce energy consumption (Case study: Rasht city). *Geographical perspective*, *16*(56), 0–4. (**In Persian**). https://elmnet.ir/doc/2374341-16563

[8] Kåknelson, H. (2010). *Climate-friendly architecture: Principles of environmental architectural design in hot regions*. Urban Planning and Architecture Study and Research Center. (**In Persian**). https://B2n.ir/ge8552

[9] Farbodmanesh, S., & Khorasanizadeh, H. (2018). Comparative study of energy consumption of different cooling and heating systems in a sample residential building using design builder software. *International conference on civil engineering, architecture and urban development management in Iran*. Civilica. **(In Persian).** https://civilica.com/doc/846575/

[10] Al-Tamimi, S. D. A., Zarkash, A., & Yeganeh, M. (1402). Analysis of the impact of green building techniques on reducing energy consumption (green roof technique in an educational building in Wasit city, Iraq). *Sustainability, development and environment*, *4*(14), 15-37. **(In Persian)**. https://elmnet.ir/doc/2565587-66991

[11] Najmeh Masteri Farahani, Daemi, A. B., & Mazandarani, M. (2023). Simulating the thermal behavior of green roofs in temperate and humid climates (CFA) (Case studies: Rasht, Durban, Tokyo, Kutaisi, Houston, Buenos Aires, Brisbane and Trieste). *Caravan*, *20*(64), 255-277. **(In Persian)**. https://elmnet.ir/doc/2783841-39199