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FUTURE HOMES WITH THE APPLICATION OF ANCIENT BUILDING EXPERIENCE, NEW STRUCTURAL TECHNIQUES, AND NATURAL ENERGY CONSUMPTION

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Highlights

- Environmentally friendly housing and landscape.
- Using renewable energy.
- Suggests innovative models using ancient techniques with new technologies.

Abstract. This study analyses some characteristics of ancient construction and clarifies how they used renewable energy in their homes. This article analyzes ancient houses that were nature-oriented and used renewable energy. This study focuses on the structural system of ancient houses in Sistan. It dissects the structural elements of the old homes. The autopsy of the ancient house structure of Sistan shows the reader the techniques used in ancient architecture to provide energy. The research methods of this article are to examine the energy supply experiences of houses in the form of a case study of an old Sistan house to discover their energy-supplying techniques. This article uses the techniques used in Sistani houses with the application of modern house-building technologies, to develop a nature-oriented model. In fact, the model presented in this article is a modernized version of the ancient house of Sistan. This model gives a house completely friendly to nature and the environment and knowledge-oriented. The model contributes to housing programs addressing new requirements. Our proposed housing model and its general principles are replicable in other regions globally to use green energy sustainably.

Keywords: housing, renewable energy, ancient structural techniques, natural resources, wind room, modernized version.

Introduction

This article analyses ancient structural techniques for use with new construction technologies in future home building. Technological advances in heating, cooling, and lighting appliances have caused housing models to distance themselves from nature-oriented construction.

However, distance influences natural resources and the environment, which has degraded natural resources and ecosystems. This fact encouraged green architecture and attention to climatic conditions and the use of natural energies (Shahraki, 2021). In recent decades, interest has increased in green housing. These efforts resulted in significant technological advances in using renewable energy in homes (Couret, 2013). One event was the COVID-19 epidemic, which drew public attention to natural resources and nature-oriented housing (Kaklauskas et al., 2021). Reducing dependence on fossil fuels and mechanical and electrical energies produced by petroleum in homes is also logical and necessary. The necessity requires using natural energies such as solar heating and wind power to eliminate environmental and economic losses. The price of houses rises parallel to increasing fossil fuels and electricity prices due to the expansion of conflicts in regions with rich oil resources (Kanwal et al., 2021). People are worried about energy supply and consumption costs. Building projects face multiple design problems, which cause expensive energy consumption. Houses that use fossil energy may create many problems for the environment, natural resources, and economy due to the high cost of fuel (Azni et al., 2023). The European green deal strives to

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decline the high dependence of residential areas on electricity, fossil fuels, and the destruction of natural resources such as vegetation, soil, and water. Other problems are air and environmental pollution and vulnerability to natural disasters. An urgent problem with housing is that it does not rely on nature. A worse crisis is the destruction of natural resources using failed construction methods. The experiences from the mentioned problems emphasize using sustainable energy in housing (Hassan et al., 2021).

The questions of this study are how we can apply ancient structural methods and techniques such as Sistan in new housing projects. How shall we benefit from our ancestors' experiences in nature-oriented housing? Scientists and engineers believe that ancient architectural practices can solve the problems of present housing, but this time with new building materials and technologies (Bozhynskyi et al., 2023). Studies on ancient homes prove that architecture uses amazing building techniques in harmony with local climates and needs (Tawayha et al., 2019). This paper hypothesizes that reusing ancient architectural techniques will correct expensive and irrational energy consumption in homes. For samples, nature-oriented ancient Sistan architecture guides the fossil-based housing energy supply and consumption. However, there has not been enough research on nature-oriented Sistan house-building techniques with advanced technologies to overcome the energy crisis. This innovative study fills the shortage and solves the housing energy supply and consumption problem by analyzing the anatomy of the ancient Sistan homes. This paper learns from energy-efficient design techniques of ancient housing but with new technologies.

The method applied in this research follows past, present, and future explorations. It explores past housing experiences to build energy-efficient homes and save ecosystems and natural environments for future generations. This study dissects the skeleton of a building left over from the Medes civilization in the Sistan plain. The dissection measures the rate of energy consumption savings by each technique used in each component of the building. Our research method is analyzing the structure of the ancient residential house aiming at designing a modern building using ancient architectural techniques. However, our case studies are limited to ancient Sistan houses. Finally, this paper presents a model of green homes by analyzing the structure of an ancient Sistan home with new knowledge, building technologies, and materials. The housing design model can be used anywhere for home building and renewable energy consumption in local situations.

1. Literature review

1.1. Housing and nature

Geographic places, local climates, and socioeconomic orderings have influenced building methods in various eras. People have patterned streets, blocks, parcels of land, and buildings according to local situations and features (Žurić et al., 2023). Ancient civilizations used natural energies in their houses in a flourishing and artistic way to provide the necessary heat and cold and comfort (Easton, 2007). Ancient China and Native Americans used natural gas and the heat of the sun to cool and cook by installing stoves in their homes (Ekouevi & Tuntivate, 2012). The ancient architecture of Iran, including Sistan, uses the natural flow of water and wind to reduce the annoying heat (Kheirabadi, 2000). Ancient Roman baths also used the gravity of the earth to flow water in the pipes and solar energy to heat it (Barbier, 2002).

Architecture and house building, however, have not always been nature-oriented like ancient civilizations. With socioeconomic changes, the discovery of fossil resources, and the industrial revolution, architecture became distant from nature, and houses no longer consume only renewable energy. Architecture chronographic review shows various correlation types between nature and architecture. In some times architecture was completely nature-oriented, in some periods less, and sometimes against natural resources. Table 1 shows 16 types of relations between nature and architecture.

Table 1. Different correlations between types of buildings and nature throughout architectural history (source: Joye, 2006)

Line	Architectural era	The type of relationship with nature
1	Cave homes	Totally in nature
2	Prehistoric homes	linked to nature
3	Ancient architecture in Greece, Rome, Egypt, China, and Iran	Benefited from natural energy wisely
4	1400 BC. Ancient Egyptian architecture	Completely nature-oriented
5	500 BC – 400 AD. Greece and European ancient architecture	Completely nature-oriented
6	771 BC – 476 BC. Traditional Chinese architecture	Completely nature-oriented
7	The architecture of the early basement life of Christianity	linked to natural energies, but less than the previous time
8	6th century. Byzantine architecture	Used huge natural water reservoirs
9	Architecture before the Renaissance, Gothic, Roman, and Byzantine	We used more natural light
10	Architecture after the Renaissance	Less linked to natural resources due to changes in the structural system of buildings
11	The first half of the 20th century. Modern architecture umbrella	It distanced itself from nature and the use of natural energy

End of Table 1

Line	Architectural era	The type of relationship with nature
12	The second half of the 20th century. Modern architecture hyper and umbrella structure	Using reinforced concrete and steel and damaging nature
13	The architecture of the industrial revolution	Had not been nature-oriented, but enjoyed technological mechanical equipment. Fights against natural resources
14	The architecture of information time	The fight against natural resources continues but public awareness concerning the distance increases
15	Contemporary housing with a critical situation in energy supply and consumption	In major cases against nature and destroys natural resources
16	Future housing architecture	More likely to use renewable natural energies by nature-oriented models

Table 1 shows 16 types of dependence of architecture on nature. It illustrates that since the industrial revolution, architectural and house-building methods have distanced themselves from nature and degraded natural resources. The devastating effects of housing have deteriorated ecosystems and made the use of natural energy mandatory (Imperatives, 1987). This ever-increasing distance has caused increasing environmental crises and numerous popular movements to preserve the land.

1.2. Housing requires natural energies

Housing faces a paradoxical problem of the expansion of cities from one side and expensive energy supply and consumption from the other. Global urbanization growth and the increasing degradation of natural resources are alarming facts. Over 75% of natural resources are consumed by cities, which occupy only 2% of Earth's land area. The world population is expected to be 80 percent urban by 2050, up from half today (Xuan et al., 2023). Recently, constructions do not respect traditional lifestyles, cultures, and habits and rely on fossil fuels. However, the expansion of centralized electricity networks operated by fossil fuels become inaccessible for many households. Recently, the price of electric energy consumption relying on fossil fuels is a global challenge that prevents urban and regional development. Therefore, many scholars and practitioners use renewable energy (Farghali et al., 2023). The increase in electricity consumption based on fossil fuels has created increasing concerns about the survival of natural resources and ecosystems and the planet as a whole (Zhang et al., 2022). The current human knowledge has explained the harmful effects of this method of energy supply which appear in the form of global warming, reduction of water resources, and natural disasters such as floods, land subsidence, destruction of forests, and fires. Because of this information, many scientists recommend that reliance on electricity from fossil fuels replaces natural energy (Gerlak et al., 2018). Recently available online facts related to energy production based on fossil fuels and naturally renewable resources in the world show still a huge dependency of communities on electricity generation through fossil fuels.

A report from the Organization for Economic Cooperation and Development (OECD) illustrates that fossil fuels will remain the main source of energy for the foreseeable future due to their higher energy density and slower pace of innovation. Nevertheless, the OECD countries have recognized the need to promote renewable energy sources. Please see the energy mix of the OECD countries in Figure 1.

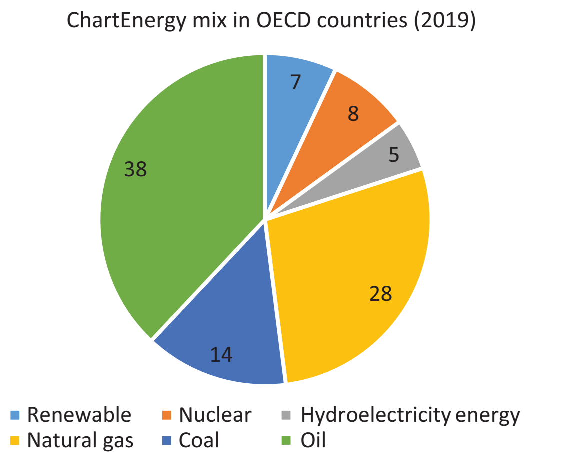

Figure 1. Energy consumption type in the OECD countries in 2019 (source: Hou et al., 2023)

Figure 1 demonstrates that fossil fuels including coal, natural gas, and oil, make up 38%, 28%, and 14%, respectively, of the energy used. This shows that 80% of the energy mix in OECD countries is fossil fuels. Figure 1 shows of course a threatening outlook in energy consumption generated by fossil fuels.

Fortunately, accelerating willingness has emerged in some countries to use renewable energies to achieve low carbon development. The countries are transiting their development plans from fossil fuel energy consumption to knowledge-based, nature-oriented, and renewable energy consumption. The countries have targeted to generate electricity with infinite natural energies.

Among 115 economies 10 countries are most prepared for the energy transition (Chenic et al., 2022; Neacșa et al., 2022). Figure 2 shows the countries.

The U.S. has also adopted policies to adapt its housing energy consumption to climate changes and the application of renewable energies. The policies targeted the use of natural infinite energy efficiency with new technologies in

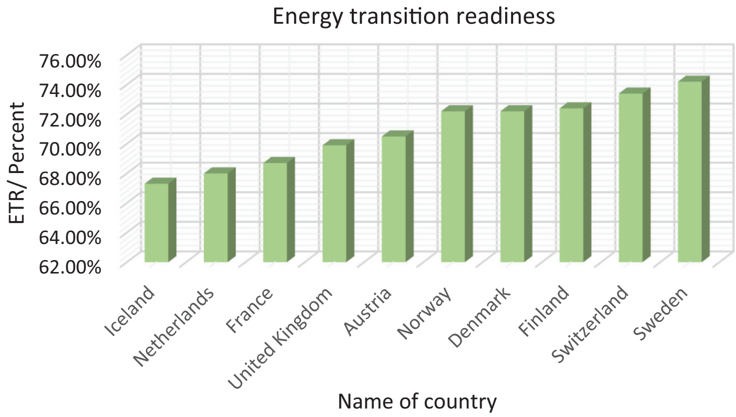

Figure 2. Top 10 countries most prepared for the energy transition (source: Neacşa et al., 2022)

low-income households. The US reduces climate change's impact on the energy sector in the following ways: saving energy, expanding access to clean technologies, modernizing infrastructure, ensuring energy equity, and making infrastructure local (Timmons et al., 2014; Aghahosseini et al., 2019). The electricity generators in Iran work with fuel oil and gas, which have caused severe pollution in the air of the cities and their suburbs. House buildings in Iran are generally dense without green spaces and without the necessary infrastructure. Studies show that Tehran is one of the most polluted cities in the world (Rahimi, 2020). Construction in Iran has caused environmental disasters, such as severe reduction of water resources, sandstorms, and increased land surface temperature (Amiraslani & Dragovich, 2023). The result of this house building and energy supply with low fossil fuel and unemployed and desperate inhabitants is severe dehydration. Iran's capital is facing a serious water shortage, water is rationed in Tehran and people are looking for some water to drink. Considering the very destructive effects of energy production by fossil fuels on natural resources and environment to the extent of threatening human existence, scientists emphasize the use of renewable energies. A future perspective, until 2050, according to estimates made by the International Energy Agency (IEA) is visible in Figure 3.

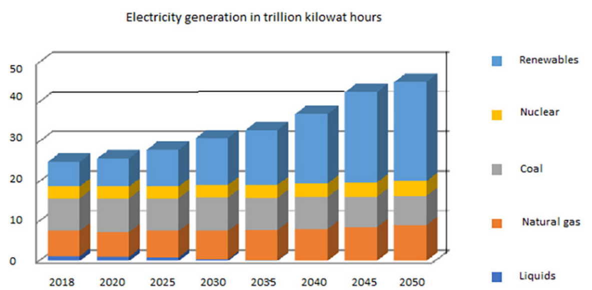

Figure 3. Worldwide projected electricity production by 2050 (source: Chenic et al., 2022)

Figure 3 shows an optimistic transition from fossil fuel-based energies toward renewable energy consumption in the world in the future.

1.3. Characteristics of ancient housing

The ancient architecture itself was the result of the gradual economic and social development of human societies, from settling in caves to the discovery of fire and agriculture, and then settling together and forming civilizations. The skeleton and form of ancient structures have been refined and evolved according to the needs of humans, climatic conditions, and local building materials. Ancient architects built astonishing architectural masterpieces such as ancient Roman cities with water and sewage piping systems, streets, and beautiful squares. They created thermal buildings, studios, and theaters that are astonishing considering the tools and technology of the time. Recently, scientists have narrated ancient Roman heritage through drawings and digital architectural representation to show the evolution process of ancient buildings (Banfi et al., 2023).

Ancient architecture met the housing requirements due to geography, climate, livelihood, and local culture. Traditional houses in India used local and natural materials, had courtyards, lattice screens to mitigate heat, projections over windows and doors to protect from sun and rain., and beautiful arches, sloping roofs, and built-in furniture (Chetia & Prashad, 2010). Ancient houses adapted to the local climate by conforming to livelihood requirements and local materials (Sözen & Gedík, 2007). The skeletons of the old structures have been formed according to the needs of the residents and the climatic requirements and local building materials. Ancient architects have left astonishing masterpieces such as ancient Roman cities with water and sewage piping systems and public buildings such as gymnasiums and theaters.

One technique used in ancient Sistan architecture was the close alignment of homes with small courtyards and high walls, which left high-shaded buildings and streets in arid regions.

Additionally, Sistan architecture used techniques of suitable locating, functional design, natural moisture, and particular ceilings, walls, beams, windows, and middle spaces to benefit efficiently from natural energies (Kaboli, 2023).

The ancient architects designed a house suitable for the local climate and placed the building in a suitable place to deal with strong sunlight and annoying winds (Hajali Zadeh, 2023). The ancient Sistan architectures designed special rooms for summer or winter living at home. The summer rooms had higher ceilings and walls and windows facing the garden. The yard, the pool, the semi-open middle space, the basement, the garden, and the plants were part of the ancient houses. These elements were installed in houses to cool the air in hot summers (Bidhendi, 2021). Other techniques that were used in the ancient houses of Sistan were the installation of ventilation for fresh air circulation and the front window to provide lighting. In addition, installing small windows in accordance with their length and width has been another wise technique in houses suitable for the ancient climate. In addition to all these techniques, ancient houses are insulated against heat, noise, and humidity using local materials.

Generally, ancient homes in the Sistan Plain used techniques of a suitable location, functional design, natural moisture, and particular ceilings, walls, beams, windows, middle spaces, and water and plants to benefit efficiently from natural energies. The following part will analyze the techniques that traditional homes use in Sistan.

2. Case studies

2.1. Sistan region

Ancient Sistan was a vast region, parts of which are located in the countries of Pakistan, Afghanistan, and Iran today. The Sistan Plain has always supplied its water from the Helmand River. The Helmand River takes its source near Kabul in Afghanistan and reaches the Yasistan Plain. Figure 4 shows the Sistan region of Iran.

Figure 4. Region of Sistan in Iran (source: Encyclopedia Britannica, 2023)

Although the Sistan region has abundant solar and wind resources to provide renewable energy, it uses fossil fuels to provide energy for homes. Sistalan is the heir of ancient architecture that makes good use of natural energies. It is interesting that the traces of this ancient architecture remain in the form of traditional houses. However, due to unwise policies, the use of fossil energy is common in this region, which has caused damage to natural resources such as water, soil, and plants. The Sistan architects designed homes, public gathering places, and bridges. They used local building materials such as sun-dried and cooked bricks. For the first time, they applied a semi-oval arch technique to design and build wider halls and porches. Architecture in Sistan used wide and tall walls with light colors to protect inhabitants from the hot weather. They designed cupolas over roofs and small windows on walls. They also applied other techniques to combat heat such as courtyards and patios. An important feature of the Sistan building methods was their functionality to supply active life necessities in production, distribution, and consumption.

2.2. Analyzing the structural system of homes in Sistan

2.2.1. Network of alleys in Sistan residential neighborhood

The passages and alleys in the residential neighborhoods were narrow with high surrounding buildings corresponding to the slope of the local lands. Usually, the alleys were oriented toward wind direction using its power to move out sand dunes.

2.2.2. The compactness of homes

The heritage of Sistan architecture shows local culture, climate consideration, and natural energy usage. Figure 5 shows a picture of a traditional residential district in the Sistan region.

Figure 5. Residential area in Sistan region (source: Afra Group, 2023)

Figure 5 exhibits some techniques used in ancient Sistan homes. Compactness and the location of homes are two visible functional techniques. The homes in the figure also have natural ventilators. Furthermore, the buildings applied local building materials. The Sistan architects applied buffer and middle spaces. They were designing the sizes and places for every opening, including wind rooms and natural light intakes. They used plants with natural moisture isolation. The ancient architects-built homes close together for security reasons. Nevertheless, the most significant reason was to protect buildings against heat and winds. This technique addressed the local livelihood needs of the people too.

2.2.3. Finding an optimal place for a home

The optimal placing of homes associated with climate factors like wind and sunshine was another building technique in ancient Sistan. The ancient architect combated climatic hardness by locating homes at the northern edge of the land.

2.2.4. Design to functional homes

Since Sistan farmers conducted some works associated with their livelihood in their homes, ancient architecture applied functional design methods. The design methods considered the livelihood of local people and the natural environment. The architects designed the indoor spaces to consume less energy. On the south side of the land, they set up living rooms and workplaces that required warm energy. They set the food store on the north side of the building since that place was colder. The Sistan functional housing plans required less energy provision.

2.2.5. Isolation with natural moisture materials

Sistan ancient architecture applied building techniques to protect the homes from heat and humidity with local natural materials. Ancient engineers applied biological techniques to isolate the buildings as well. They used natural materials such as natural cement called Sarooj. They also used buffer spaces to prevent noise pollution where necessary. The ancient architects of Sistan used the art of architecture in determining the location of the building and designing some rooms in the basement of buffer spaces to create peaceful spaces. They have also used structural techniques such as broken buildings, thick load-bearing walls, and closed facades to provide buffer spaces. Furthermore, they used natural vegetarian poisons against ants and insects in the wooden elements of the buildings.

2.2.6. Walls and beams

Ancient architects-built homes with wide shear walls and arched beams to stand static against earthquakes, storms, and various tensions.

2.2.7. Ceiling of homes

The ceilings of the buildings were in the form of dome roofs. The domed roofs were skillfully constructed from local buildings with clay and mortar materials, and a mud-straw coating insulated the surface of the domed roof from rain and moisture.

a) Section b) Interior view c) Front view

Figure 6. A windward ventilator called Kolak in Sistan local language (source: Sargazi et al., 2022)

2.2.8. Natural ventilators

One interesting and effective energy-saving technique in homes was natural ventilators. The ventilators could be of various sizes, shapes, and forms. The ventilators used local wind power to cool the homes. Figure 6 exhibits front, interior, and section views of general ventilation on the roof of one room.

Figure 6 shows that ancient Sistan homes used cupola roofs with a small window (Kolak) as a ventilator at the center of the cupola. The ventilators directed the air into the home or sucked the air into the building. The fresh air could circulate by the inlet and outlet channels visible the part (a) of the picture, the section view.

2.2.9. Small windows on the top of outer walls

The ancient architecture in Sistan placed small windows of suitable sizes on the top of the outer walls of homes. The windows transferred air into the building free of heat and dust. The windows could provide natural light daily while cutting the direct heat and light. Architects directed windows toward the sun while using trees to shade windows and roofs during summer. Observations of their remaining houses show that they benefited from maximum solar energy in winter with this technique.

2.2.10. Building technique of wind rooms

Buildings in the Sistan plain used wind rooms to cool homes. It was a technique that cooled the rooms with water and wind. The wind room building technique still exists in parts of the Middle East region. Usually, the winding room is located directly under the ventilator (Kolak) at the bottom of the home. Water and air circulated into the wind, making cool air naturally. The architects placed rooms around the wind room, and cool air flowed into them.

2.2.11. Building technique of middle spaces

Usually, ancient homes in Sistan are two-story buildings. People used the first floor for domestic animals but the second floor for family living. Simultaneously, the two-story buildings had a middle space located between the garden and the home. The space that was a balcony was in front of the home called Dakoncha. They usually built a short wall around the Dakoncha with a height of approximately a half meter.

2.2.12. Provision of natural light

As we mentioned earlier, ancient homes in Sistan provided natural light with building techniques like Kolak, small windows on the top of outer walls, and middle spaces. The mentioned building techniques provided natural light for Sistan homes with rays of sunshine during the days and moonlight at night.

2.2.13. Climate-friendly building materials

Ancient Sistan homes were built with local building materials. Building materials such as mud, clay, wood, and colors were used in the homes. The building materials were environmentally and climate-friendly. The mentioned materials could retain heat and cold in themselves. Clay was a primitive building material that people applied to build bricklayers. The bricklayers were compressed solidly. People molded mud gradually and allowed it to dry. Ancient builders blended straw, clay mud, and water carefully to supply a strengthened mortar. The process to provide the mortar sometimes took one month.

2.3. Modern housing model with renewable energy consumption

This section of the paper designs a housing model according to lessons such as the site selection technique and the use of natural light and wind from ancient Sistan. After a site selection and design of the house, the measures for the windows and doors have been specified. The proposed house model has two floors and a middle space. It has store places for food on the ground floor. The upper floor has bedrooms, living rooms, a digital room, and a bath. We have applied the building technique of the natural ventilator in the building. The ventilator function is exhibited in Figure 7. The cross-section of the building shows a fountain in the center of the wind room and windows around it. When the air flows down to the water, it makes the air cool.

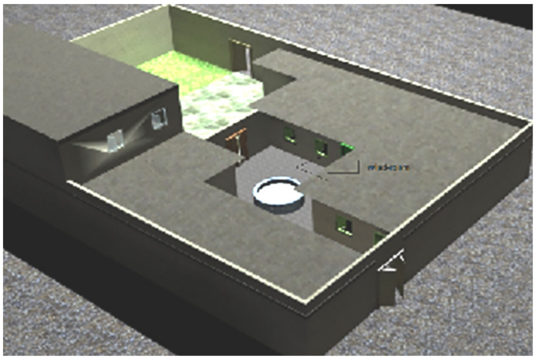

Figure 7. A modern version of the ancient natural ventilator with new building materials and technologies

Our proposed housing model is based on building techniques applied by ancient Sistan homes that aim to use natural energies. The model considered the local economy, lifestyle, and climate. Figure 8 shows well our proposed model in two stories. The figure shows that the modern version of the ancient Sistan home used building materials and colors that are pertinent to the local climate and environment. In this building, instead of traditional building materials, we use modern construction materials according to the technical analysis of the structure. New materials that can be used in the climate of Sistan are, i.e., bending and flexible concrete, light composite prestressed concrete, transparent wood, laminated wood carbon fiber, self-healing concrete, durable paper composite material, liquid granite, transparent aluminum, hydrodynamics, etc. We designed the home for living and working in one household according to regional customs and livelihood types.

Figure 8. Front view of a modernized version of the ancient Sistan homes

Figure 8 shows that our proposed home building model reduces the sizes of the outer openings at a suitable measure to protect the inhabitants against heat and wind.

2.4. Analyzing the benefits of ancient Sistan housing techniques in the household economy

To calculate the economic benefits of using natural energy in homes instead of fossil fuels, we consider the price of kerosene, which is \$0.5 per liter in Sistan. On average, each family of 5 people spends 600 liters per month on heating, cooling, and lighting the house. The energy cost of a home in Sistan is 3,600 dollars. Table 2 shows the saving rate by applying each ancient structural technique.

Table 2. Rate of saving energy by the application of ancient structural techniques

Line	Name of structural technique	Rate of saving energy
1	Suitable localization of homes	12.5
2	Functional design	9.25
3	Natural moisture isolation	9
4	Walls and beams	9
5	Celling of homes	7.75
6	Natural ventilators	7.75
7	Suitable size and place for windows	8.25
8	Using wind rooms	10.50
9	Using middle spaces	7.40
10	Using natural light	9.10
11	Applying suitable building materials	9.50

Here, we make a mathematical model whose Equation (1) calculates the economic savings resulting from each of the 11 techniques used in the houses of Sistan. In Equation (1), the total impact of economic savings caused by 11 techniques is 100%. Here, we make a mathematical model whose Equation (1) calculates the economic savings resulting from each of the 11 techniques used in

Sistan's houses. In Equation (1), the total savings is 100%.

$$\rho_n = \sum_{i=1}^{n} \rho_i = \left(\rho_1 + \rho_2 + \rho_3 + \ldots + \rho_{n-1} + \rho_n\right). \quad (1)$$

In function (1), ρ_i denotes the effectiveness rate of each technique and n is the number of techniques. We continue the modeling with Equation (2), which calculates total economic savings using the n techniques applied in ancient Siatan home

$$\sum_{i=1}^{n} Es_i = \frac{\rho_1 \times T + \rho_2 \times T + \rho_3 \times T + \ldots + \rho_{n-1} \times T + \rho_n \times T}{100}. \quad (2)$$

In Equation (2), Es_i denotes the economic savings resulting in every technique. Simulating the model presented in (1) and (2) in Equations (3)–(13) with particular data of Sistan homes gives economic savings by every one of the 11 techniques applied.

$$Es_1 = \frac{\rho_1 \times T}{100} = \$450; \quad (3)$$

$$Es_2 = \frac{\rho_2 \times T}{100} = \$333; \quad (4)$$

$$Es_3 = \frac{\rho_3 \times T}{100} = \$324; \quad (5)$$

$$Es_4 = \frac{\rho_4 \times T}{100} = \$324; \quad (6)$$

$$Es_5 = \frac{\rho_5 \times T}{100} = \$279; \quad (7)$$

$$Es_6 = \frac{\rho_6 \times T}{100} = \$279; \quad (8)$$

$$Es_7 = \frac{\rho_7 \times T}{100} = \$297; \quad (9)$$

$$Es_8 = \frac{\rho_8 \times T}{100} = \$378; \quad (10)$$

$$Es_9 = \frac{\rho_9 \times T}{100} = \$266; \quad (11)$$

$$Es_{10} = \frac{\rho_{10} \times T}{100} = \$328. \quad (12)$$

Finally, the model calculates the total economic savings using by the 11 techniques of the ancient Sistan homes in Equation (13).

$$T = \sum_{i=1}^{11} Es_i = \frac{\rho_1 \times T + \rho_2 \times T + \rho_3 \times T + \ldots + \rho_{10} \times T + \rho_{11} \times T}{100} = \$3600. \quad (13)$$

This cost, \$3600 is 88% of the average Iran GPD per capita, which is equivalent to \$4091.2 and expensive for the people of Sistan (Domeyer et al., 2018).

3. Findings and discussions

The study and analysis of housing in ancient Sistan showed that architects applied amazing and rational building techniques to sustainably consume natural energies. We analyzed 11 of these ancient building techniques and found them helpful in future house building. We found that using renewable energy to make buildings comfortable for residents with optimal productivity is important principal. Table 2 and the model developed in Equation (1) show that the 11 ancient structural techniques will be beneficial in modern house constructions. Simulating the model in the special situation of the Sistan region showed that 11 techniques resulted in savings equal to 3600 US Dollars average for every household. This study presumed that ancient home-building techniques with new knowledge and technologies save nature and the natural environment and benefit economically. Of course, the house-building of ancient Sistan that we analyzed in Section 2.3 reduces the fossil energy crisis and ecosystem and environmental threats to the planet. New studies conducted by scientists and experiences also confirm our hypothesis. A study concerning the benefits and feasibility of renewable energies in urban buildings conducted an economic analysis concerning hybrid renewable systems. The study proposed a model with time series to forecast the electricity market in Finland. Technoeconomic assessment of hybrid renewable systems showed a reduction of the initial investment of deep geothermal resources by about 30% supported by public funding, which presents the real cases in Finland (Lu et al., 2023). Aftermath the recent emerging hazardous impacts of fossil fuels on the natural environment, the government of Finland encourages renovation projects. Finland's public funding for deep geothermal energy projects is available to leverage very high investment. Figure 9 shows the annual energy cost in Finland.

Figure 9 shows the outcome of the support policy. Finland now promotes the provision of energy by the mixed centralized geothermal and grid technology (2 boreholes plus purchased electricity). The outcome of this study in Finland verifies our hypothesis that promotion of renewable energy is both economic and environmental. Furthermore, scholars applied ancient home-building techniques and found that these procedures reduce dependency on fossil fuels with negative multidimensionally impacts on renewable energies. For example, they studied ancient housing techniques in Basra, Iraq. They analyzed the heating, cooling, and lighting methods of homes with natural resources and found them highly beneficial compared to fossil fuels. Housing with renewable energy consumption has also been examined earlier in other corners of the world. Green building has undergone breakthroughs in Stockholm and throughout Sweden, which have resulted in building materials and technologies to considerably supply renewable energy (Metzger & Olsson, 2013). Nature-oriented architecture saves natural resources and improves existing housing issues. Scholars believe that renewable energy is required to the existing natural

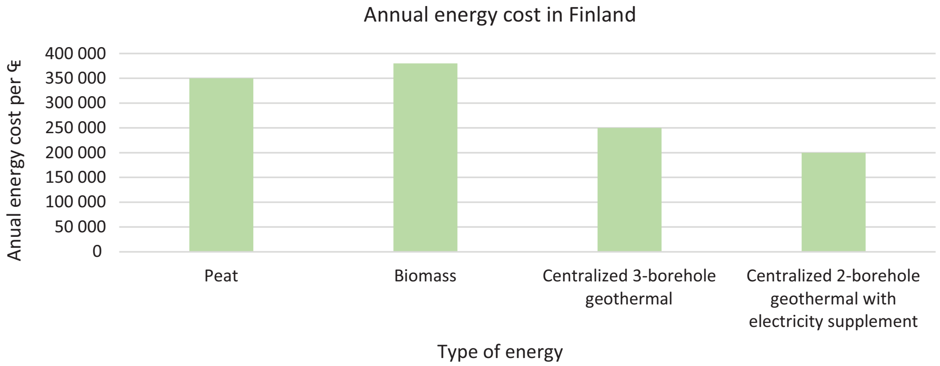

Figure 9. The annual energy of various renewable energies per € (source: Lu et al., 2023)

resources (Pan, 2016). However, contemporary housing relies on harmful fossil fuels. This paper designs a home with ancient building techniques connected to nature but with new technologies and building materials.

The techniques that ancient housing applied to build comfort with the help of nature mentioned in Section 2.3 contributed to design a green home with renewable energy consumption. The ideas of scholars, literature review, experiences, and observations proved that housing with renewable energy consumption will be functional, rational, and economic (Judson & Zirakbash, 2022; Drabecki & Toczyłowski, 2022). When economies are in trouble, fossil fuels are limited and costly, and nature has been threatened critically, returning to nature is a rational, economic, and modern way to supply energy for homes. Figures display a modernized version of ancient housing that we learned from ancient Sistan and new building technologies.

The techniques of ancient Sistan architecture, such as the climatic placing of buildings, shaping suitable building forms, thermal functioning arrangement of indoor places, ceiling models, natural ventilators, and techniques of fitting openers, roofs, and wind rooms, are feasible in new constructions. The new housing model uses renewable energies such as sunlight and wind power to save natural resources, the ecosystem, and the environment and benefit economically. This pilot model of housing is a green building that reduces anthropogenic impacts on nature and the environment.

Conclusions

This article analyzed the multidimensional harms of fossil fuel consumption in housing and the problem of the high cost of energy supply and consumption because of the current regional crises. It hypothesized that the housing techniques of ancient civilizations, which used natural energy such as light, solar heat, wind power, ground heat, and architecture suitable for indigenous conditions, could solve many housing problems through the application of modern technologies. This paper presented a home designed by a combination of ancient techniques and new building knowledge. The research analyzed the structures of ancient houses to determine what they used to achieve stability and strength for the building as well as comfort and safety for its inhabitants. Section 2 of this article analyzed techniques used in the ancient house building of the Sistan region of Iran to learn for the modern model presented in this article. The model developed in this article for housing was a house designed using the green architectural experiences of our ancestors and new technologies and modern building materials. The house model relies on nature and consumes renewable energy. Additionally, the model does not harm the ecosystem, environment, and natural resources. Experiences of economic and environmental preference for renewable energy in the USA, Sweden, China, Japan, and Saudi Arabia proved the theory that ancient architectural techniques with modern technologies and building materials would pave the way for nature-based housing. In the future, research shall be conducted concerning each ancient housing technique analyzed in Section 2 of this article, aiming at its application in modern housing with renewable energy supply and consumption.

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